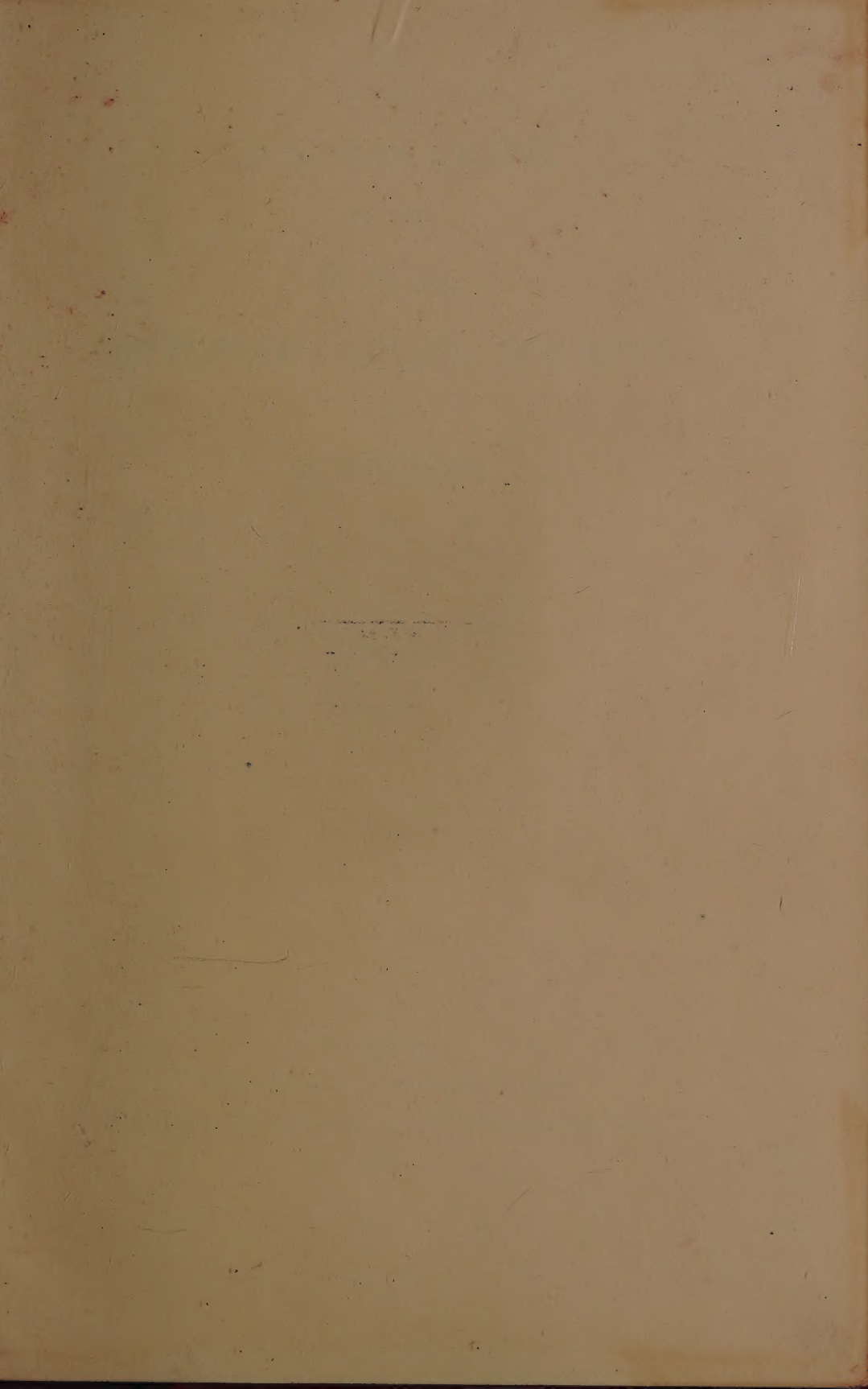


COMM. INST. ENTOM
— LIBRARY —

No. 9397



THE
TRANSACTIONS
OF THE
ROYAL
ENTOMOLOGICAL SOCIETY
OF
LONDON

VOL. 96

LONDON:
PUBLISHED BY THE SOCIETY AND
SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

1946

PRINTED IN GREAT BRITAIN BY
RICHARD CLAY AND COMPANY, LTD.,
BUNGAY, SUFFOLK.

CONTENTS

	PAGE
BENSON, Robert B., M.A., F.R.E.S. Classification of the CEPHIDAE (Hymenoptera Symphyta)	89
BROWN, E. S., B.A. The variation of <i>Glaenocoris</i> a Thomson (Hemipt., CORIXIDAE) in the British Isles, and its probable cause	1
CORBET, A. Steven, D.Sc., Ph.D., F.R.I.C., F.R.E.S. Observations on the Indo-Malayan species of the genus <i>Arhopala</i> Boisduval (Lepidoptera : LYCAENIDAE)	73
EVANS, J. W., M.A., D.Sc. A natural classification of leaf-hoppers (Jassoidea, Homoptera)	47
FRASER, Lt.-Col. F. C., I.M.S. Retd., F.R.E.S. Notes on Amazonian Odonata in the Leeds Museum	11
GARDNER, J. C. M., C.I.E., F.R.E.S. On larvae of the NOCTUIDAE (Lepidoptera)—I.	61
HINTON, H. E., B.Sc., Ph.D., F.R.E.S. A synopsis of the Brazilian species of <i>Elsianus</i> Sharp (Coleoptera, ELMIDAE)	125
SOMEREN, E. C. C. van. Ethiopian CULICIDAE : notes and descriptions of some new species and hitherto unknown larvae and pupae (Diptera)	109
WILTSHIRE, E. P., F.R.E.S. Studies in the geography of Lepidoptera.—III. Some Middle East migrants, their phenology and ecology	163
ZAKHVATKIN, A. A., D.Sc. Notes on some Homoptera from Yemen	151
GENERAL INDEX	183

PUBLICATION DATES OF TRANSACTIONS
VOLUME 95, PARTS 7 AND 8.

The attention of Fellows is called to the fact that Parts 7 and 8 of the *Transactions*, Volume 95, dated 31st December, 1945, were actually available at the Society's rooms on that day, although despatch to Fellows could not be made until the end of January.—N. D. RILEY, *Hon. Secretary*.

1 MAY 1946

Eu. 344.

Vol. 96. Part 1. Pp. 1-10, 1 pl., 1 fig.

April 15th, 1946.

THE
TRANSACTIONS
OF THE
ROYAL
ENTOMOLOGICAL SOCIETY
OF
LONDON

World List abbreviation: *Trans. R. ent. Soc. Lond.*

CONTENTS

+ BROWN, E. S., B.A. The variation of *Glaenocoris* Thomson (Hemipt., CORIXIDAE) in the British Isles, and its probable cause.

PAGE

1-10, 1 pl., 1 fig.

LONDON:

PUBLISHED BY THE SOCIETY AND
SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 4s. 0d.

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Founded, 1833. Incorporated by Royal Charter, 1885.

PATRON—HIS MAJESTY THE KING.

OFFICERS and COUNCIL for the SESSION, 1946–1947.

PROF. G. D. HALE CARPENTER, M.B.E., D.M., *President*.

W. J. HALL, D.Sc.

C. B. WILLIAMS, M.A., D.Sc. } *Vice-Presidents*.

H. B. WILLIAMS, LL.D. }

A. WELTI, *Treasurer*.

N. D. RILEY, *Secretary*.

Other Members of Council.

C. H. ANDREWES, F.R.S.

J. W. EVANS, M.A., D.Sc.

G. FOX-WILSON, N.D.H.

R. M. GREENSLADE.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

CAPT. R. A. JACKSON, R.N.

MISS C. E. LONGFIELD.

SIR GUY A. K. MARSHALL, K.C.M.G.,

D.Sc., F.R.S.

G. E. J. NIXON, B.A.

J. F. PERKINS, B.Sc.

F. J. GRIFFIN, A.L.A., *Registrar*.

Finance and House Committee.

G. FOX-WILSON, N.D.H. (Chairman).

J. W. EVANS, M.A., D.Sc.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

W. RAIT-SMITH.

O. W. RICHARDS, M.A., D.Sc.

Publication and Library Committee.

W. J. HALL, D.Sc. (Chairman).

H. E. HINTON, B.Sc., Ph.D.

B. M. HOBBY, M.A., D.Phil.

J. F. PERKINS, B.Sc.

J. SMART, B.Sc., Ph.D.

W. H. THORPE, M.A., Sc.D.

Committee on Generic Nomenclature.

FRANCIS HEMMING, C.M.G., C.B.E. (Chairman).

W. A. F. BALFOUR-BROWNE, F.R.S.E.

K. G. BLAIR, D.Sc.

O. W. RICHARDS, M.A., D.Sc.

N. D. RILEY (Secretary).

Committee for the Protection of British Insects.

H. M. EDELSTEN, O.B.E. (Chairman).

R. B. BENSON, M.A.

E. A. COCKAYNE, M.A., M.D., F.R.C.P.

CAPT. R. A. JACKSON, R.N.

COL. F. A. LABOUCHERE.

A. M. MASSEE, D.Sc.

THE HON. MIRIAM ROTHSCHILD.

W. H. THORPE, M.A., Sc.D.

N. D. RILEY (Secretary).

The Executive Officers of the Society are *ex-officio* members of all Committees.

DELEGATES OF THE SOCIETY TO:

1. British National Committee for Biology (Royal Society).

Sir Guy A. K. Marshall, K.C.M.G., D.Sc., F.R.S., appointed 1939.

Dr. V. B. Wigglesworth, M.A., B.Ch., M.D., F.R.S., appointed 1943.

2. Local Committee of Management of Wicken Fen.

Mr. H. M. Edelsten, O.B.E. [nominated by Committee for the Protection of British Insects].

3. National Trust for Places of Historic Interest or Natural Beauty.

Mr. H. M. Edelsten, O.B.E., appointed 1944.

4. New Forest Association.

Mr. W. Fassnidge, appointed 1934.

5. New Forest Joint Committee.

Mr. W. Fassnidge, appointed 1939. Dr. F. J. Killington, D.Sc., A.L.S., appointed 1939.

6. Royal Meteorological Society. Phenological Committee.

Dr. C. B. Williams, M.A., D.Sc., appointed 1937.

7. Joint Bioclimatic Committee.

Prof. P. A. Buxton, M.A., F.R.S., appointed 1941.

8. Council for the Promotion of Field Studies.

Dr. W. H. Thorpe, M.A., Sc.D., appointed 1944.

9. Joint Bioclimatic Committee.

Dr. B. P. Uvarov, C.M.G., D.Sc., appointed 1945.

Dr. C. B. Williams, M.A., D.Sc., appointed 1945.

TRANSACTIONS
OF THE
ROYAL
ENTOMOLOGICAL SOCIETY
OF LONDON

VOL. 96.

1946.

THE VARIATION OF *GLAENOCORISA* THOMSON (HEMIPT., COR-
IXIDAE) IN THE BRITISH ISLES, AND ITS PROBABLE CAUSE

By E. S. BROWN, B.A.

Manuscript received 9 August, 1944.

(Read 27 April, 1945.)

WITH 1 PLATE.

It has long been realised that *Glaenocorisa* in Europe is represented by two forms, variously regarded as species, subspecies or varieties; some authors have referred two European species to the genus, viz. *cavifrons* Thomson (a dark form), and *propinqua* Fieber (a pale one). Jaczewski (1924) regarded *propinqua* as differing from *cavifrons* only in its paler colour; Hutchinson (1924) described the variation in the British Isles in detail and pointed out (1928) how "a large dark form exists in the Highlands of Scotland and Islay, and that specimens from Jura and Westmorland form a series leading to the smaller, paler form of Southern England"; he believes that these dark and pale forms are identical with the European *cavifrons* and *propinqua* respectively, and considers them to be sufficiently distinct to be regarded as separate subspecies, which he names *Glaenocorisa cavifrons cavifrons* Thomson (dark form) and *G. cavifrons propinqua* Fieber (pale form); he admits, however, that examples from Jura and Westmorland are intermediate, with a tendency towards *cavifrons* and *propinqua* respectively. China (1943) states that Hutchinson "has suggested that the pale southern form of *G. cavifrons* Thomson 1869 is a distinct species," which is an error, for what Hutchinson stated was that "the two extreme forms are so distinct in appearance that they would be readily mistaken for distinct species superficially, and are certainly entitled to subspecific rank." In his recent check-list (1943) of the British species, however, China admits only subspecific distinction, and he points out that since the name *propinqua* has priority to *cavifrons*, the species must be called *G. propinqua* Fieber 1860; the type of the species is thus the pale form and not the dark one, which becomes a subspecies *G. propinqua cavifrons* Thomson

1869. This, then, is how the matter rests at the present time, but Hutchinson (1928) states that "the case needs further investigation, for the distribution of the races suggests that they have each entered Britain by separate routes and that later a partial fusion has occurred." An opportunity to investigate further the situation regarding this species in southern Scotland has led to some interesting results; for it was found that great variation occurred within this area. The extent of this variation is now to be described, and followed by the conclusions reached regarding its nature and cause.

An Account of the Variation.

The variation of those specimens which have been studied appears to involve colour only. Preparations of the male palae and genitalia have been made for the microscope from examples of the palest and darkest forms found, and no structural difference has been detected.

The colour-variation is the result of variation in the extent and in the intensity of the pigmentation, and different parts of the insect are affected in slightly different ways as described below; for purposes of comparison, examples chiefly used were the darkest and palest forms I have seen, from Cran Loch (Dumfriesshire) and Branhholme Wester Loch (Roxburghshire) respectively.

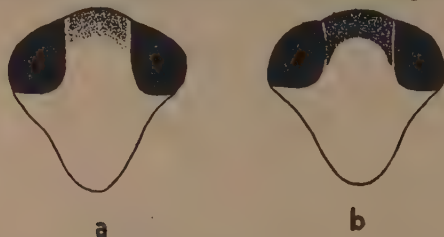


FIG. 1.—Drawings of front view of head of *Glaenocoris propinqua*: (a) from Branhholme Wester Loch (Roxburgh), (b) from Cran Loch (Dumfries); showing extent and intensity of the pigmentation of the top of the head.

(i) *The hemelytra.* The striking difference between extreme forms of the elytra appears to be due chiefly to variation in extent, rather than in intensity of pigmentation, of the pale lines: this is indicated in Plate I (a), from which it is seen that in the dark form the pale lines are very much narrower than in the lighter-coloured ones; there is also, however, a deepening in colour of the dark areas in very dark specimens, associated with a very glossy appearance and a purple sheen, which is very striking and beautiful in the living insect under water, with the sun shining on it and viewed from the correct angle; pale specimens have this purple sheen, but to a much less extent; I have noticed it also in specimens of *Corixa carinata* Sahlberg from peaty pools.

(ii) *The pronotum.* In pale specimens the pale transverse lines of the pronotum stand out as distinctly as they do in any species of the genus *Corixa*; in dark specimens they are hardly distinguishable, which is due, as far as one can see, partly to a narrowing of these lines, but also to a general infuscation throughout each line, which in extreme cases makes it indistinguishable in depth of colour from the dark lines on either side.

(iii) *The head.* The head between the eyes is always more or less infuscated. The extent of the infuscation downwards on to the front of the face varies little from dark to pale specimens, but the intensity differs considerably.

In pale forms (fig. 1 (a)), the intensity distinctly fades off towards the lower margin, on the front of the face between the eyes, and also laterally as the eyes are approached; in dark examples (fig. 1 (b)), the infuscation is so intense as to appear practically jet-black, being about as dark in colour as the eyes themselves. On the top of the head towards the hind end, just in front of the hind border, is a pale area which varies both in intensity and extent with the general colour of the insect, but it always remains visible as a yellowish area even in the darkest specimens. The hind border itself is black in dark specimens, and lightly infuscated in pale ones.

(iv) *The legs.* The middle and hind legs vary in shade fairly considerably, the differences being due to changes in the intensity of the pigmentation. Variation affects chiefly the tibia and the distal end of the femur, and in the middle leg the tarsus is also deeply infuscated in dark examples; it is noteworthy that these are in the living insect the only parts of the legs normally visible, for the hind tarsi, which are hardly, if at all, affected by the infuscation, are covered up at least partially by the swimming hairs, which are always dark-coloured; these variations are shown on Plate I. (b) and (c), though the difference between extreme forms does not show up in as striking a manner in photographs as in the insect itself.

In the front legs variation is very slight compared with that in the middle and hind legs; in pale examples there is little or no infuscation, while in dark ones there is a certain amount of pigmentation on the outer (post-axial) side of the femur and tibia, and on the outer proximal angle of the pala; here again, be it noted, the visible parts are those which tend to be affected, for the front legs are normally flexed under the head and only the post-axial surfaces of the femora and tibiae are visible.

(v) *The underside.* The palest Scottish examples from Branhholme Wester Loch have no ventral infuscation at all. The darkest ones have a rather dark, blackish pigmentation on the underside of the thorax, and of the first few abdominal segments, but the depth of pigmentation lessens towards the tip. Just how far the underside should be regarded as "visible" in ordinary circumstances is debatable; it should be remembered that *G. propinqua* spends much of its time cruising about in open water, and the underside is then visible to any animal beneath, but from below the insect will be seen against a light background and a pale colour would therefore appear to be of greater advantage; on the other hand, pigmentation is frequently found on the underside of species of CORIXIDAE which spend more time on the bottom (it is normally evident in *Corixa carinata* Sahlberg, and in *C. germari* Fieber I have found partially pigmented as well as unpigmented conditions). In view of these considerations, one cannot regard pigmentation of the underside in dark specimens as an advantage on a dark background (unless shown to be so in some other way), but rather as part of a general increase of pigmentation acquired in development in relation to the depth of colour of the bottom (see Popham, 1941). The variation of this and other features will be made more clear later when considering the causes of colour variation.

It is of the utmost importance to realise that the differences described above are only (a) differences in colour, and (b) differences of degree, for out of over 150 specimens examined in connection with this study, a more or less complete gradation between the two extremes has been found. It will be convenient for the remainder of this paper to have a method of assessing, for numerical and precise comparative purposes, the degree of pigmentation in any given specimen of *Glaenocorisa*. A simple one is available in the Ostwald

Colour System, employed for similar purposes and described by Popham (1941). The insect is compared with a standard series of grey powders of different shades, until one is found which matches it best for depth of colour; each colour in the series is designated by a letter, and so each insect can be allotted its colour value in terms of these letters. Specimens of *Glaenocoris* were found to vary between colour "1" (the palest), and "o" (the darkest); it is not always easy to allot an exact standard to any one insect, and it is then stated to be between two standards, e.g., "1-m" (see Table 1).

TABLE 1.

Showing relationship between colour of insects, colour of background, and pH.

Habitat	Colour of back-ground	pH value	Number of individuals in colour-groups						
			1	1-m	m	m-n	n	n-o	o
Branxholme Wester Loch	1	8.0	6	29	2				
Cleuchhead Loch	n	5.5				1	1		
Loch Neldricken	n	5.4					10		
Troston Loch	n	6.1					2	8	
Black Loch	n	6.5						3	1
Garwachie Loch	n	6.5						1	1
Loch Eldrig	n-o	6.5						2	10
Peat Loch on Cairn Hill	n-o	4.0 or less							3
Loch Heron	o	6.5					8	17	
Cran Loch	o	4.0 or less						4	63

The Geographical Distribution of Colour-Variations.

On the continent the dark form occurs in North Europe, and the pale one has a more southerly distribution (Hutchinson mentions Austria). In the British Isles present knowledge of the distribution has been indicated in the Introduction; it is generally considered that, as on the mainland of Europe, the dark form is northern and the pale form southern, and Hutchinson's observations imply that there may be a geographical gradation between, thus conforming to a "cline" in Huxley's sense (1942); but he suggests that such a condition may have arisen by the dark form entering Britain in the north, and the pale form in the south, and the two forms subsequently spreading south and north respectively to a point of overlap, and interbreeding where they met to produce intermediate forms. If this were the case, the state of affairs would be similar to that in the two races of Crow, *Corvus corone corone* (Carrion Crow), and *C. c. cornix* (Hooded Crow) which interbreed, where their ranges have joined, to produce intermediate forms.

The examples of *Glaenocoris* which I have collected or seen myself, and of which the colour has been estimated, provide some interesting data for comparison with the above ideas. Most of my collecting, so far as this species is concerned, has been done in south-western Scotland. Having regard to previous ideas on the subject I wished to see what form of the species would turn up in this area, as it was thought possible that intermediates between *propinqua* and *cavifrons* might occur. It was therefore of great interest to

find a great variety in different habitats, not very far from one another geographically, the insects conforming to colour-standards from "1" to "o," with more or less of a complete gradation between (see Table 1); but all the insects from any one habitat were strikingly constant in colour. From other parts of the British Isles I have seen no paler nor darker examples than the extreme forms obtained from this area, and since insects coloured "o" are practically jet-black, it is unlikely that any darker ones will be found: those from the south which have been estimated for colour are mostly fairly considerably darker than those from Branzholme Wester Loch, and the figures set out below enable a comparison to be made between those from south-west Scotland (Table 1) and those from farther south.

	l-m	m	m-n	n	n-o
Dartmoor (South Devon) . . .	3.	10	2		
Glyder fawr (Caernarvon) . . .				1	
Priddy Pool (N. Somerset) . . .				1	2
Killarney (S.W. Ireland) . . .					3

The range of colour shown is seen to be within the range found in south-west Scotland only, indicating that any idea of a gradation from north to south is erroneous, and that some reason other than a partial fusion of two geographical races must be sought for the variation exhibited by this Corixid.

The Cause of Colour Variation.

The causes of any original variation may be either genetic (the variation being then hereditary) or environmental. Now if in the present instance the cause were genetic, one would not expect to find conditions such as prevail in S.W. Scotland; it will be seen from Table 1 that, for a given habitat, depth of colour in *Glaenocorisa* is amazingly constant, but it may differ considerably from that found in other habitats not very far distant. Although (for reasons which cannot be discussed in detail here) *Glaenocorisa* probably migrates little, there is very little doubt that migration does occur to a certain extent; and the consequent mixture of populations would result (if colour were dependent solely on genetic factors which are perpetuated from one generation to the next, and produce their phenotypic effect in any environment) in fairly considerable colour variation within each habitat; but the constancy within each habitat is so striking (and it is more so when the insects themselves are examined) that one can only suppose that the degree of pigmentation is determined by the particular environmental factors obtaining in the water-body itself.

What, then, are the environmental conditions at work? Such factors as have been previously adduced, or which seem to me to be likely to take effect, will now be enumerated and discussed in turn.

(a) *Latitude.* As has been stated before, it has been sometimes assumed that the pale form is more or less exclusively southern and the dark one northern, which implies, unless the forms are regarded as different species which do not interbreed, that some factors dependent on latitude (and hence presumably climatic) affect colour. This possibility, however, is denied by the existence of extremes of colour variation in S.W. Scotland at approximately the same latitude, and the existence there of forms lighter than any I have seen from farther south.

(b) *Acidity of the water.* Hutchinson (1924:24) suggested that in *Corixa striata* L. (and presumably he intended his ideas to apply to other species of CORIXIDAE) the variation in intensity and degree of spreading of the dark markings was due to acidity in the water rather than mere absence or presence of peat: in other words, a low pH value (high acidity) should be associated with dark colour, and *vice versa*. Although this happens to be true very approximately, the reason for the correlation is indirect, and extensive observations, in South Scotland and other districts, on pH values of water-bodies, harbouring Corixids has brought to light instances which show clearly that acidity is not the primary factor concerned; a striking example concerns *Corixa concinna* Fieber, which was represented by considerably darker specimens in water of pH = 7.0 than in water of pH = 6.5 (see Table 2); such instances of the "reversal" of the normal correlation could be multiplied for other species (e.g. *Corixa distincta* Fieber).

(c) *Colour of the background.* Dr. E. J. Popham (1941 and 1943) has produced a considerable body of evidence to the effect that colour in many species of CORIXIDAE (his work applies in particular to *C. distincta*) is closely associated with the colour-tone of the background, dark specimens being found over dark bottoms and pale ones over lighter bottoms. It was after noticing the variety in *Glaenocoris* in south-west Scotland and trying, without complete success, to correlate the variety with the pH value of the water-bodies, that I first became aware of his work. By means of a series of tubes containing grey powders of various shades conforming to the standards in Ostwald's Colour Chart, similar to those used by Popham, I then obtained an estimate of the colour-standards of the bottoms of all the habitats encountered which contained *Glaenocoris*, and also estimated the colour-standards of the insects themselves. The results are set out in Table 1, from which it can be seen that there is a fairly close agreement between the colour of the insects and that of the background over which they live; such discrepancies as exist (e.g. Loch Heron) may be due to the effect of other factors as well, but are more likely to be due to slight inaccuracies in estimation of the colour of the background, since the difficulty of carrying out this estimation in the field is great, especially over the darker range of colour, or when climatic conditions and light are unfavourable.

Table 1 includes also the pH values of the various water-bodies, and so some interesting comparisons can be made: it can be seen that there is also a rough correlation between the colour of the insects and acidity (that is to say, an inverse relation between colour and pH); but there are some rather serious discrepancies in this case; the pH values were determined in the field by using British Drug Houses "Universal Indicator," and I have satisfied myself, by estimation of solutions of pH value subsequently tested by accurate means, that such estimations are accurate to within ± 0.2 at most, and in nearly all cases much more accurate than this. The bugs from Cleuchhead Loch, Loch Neldricken and Troston Loch, for instance, are much paler than those from Loch Eldrig, though the water was more acid; Loch Neldricken and Troston Loch were interesting in that the bottom was made up of two components as far as colour is concerned,—a pale background (white sand, colour "i" in the case of the former) overlain with much darker moss (Troston Loch) or *Sphagnum-detritus* (Loch Neldricken); since the *Glaenocoris* were nearly all taken from the dark component the true colour was taken as an intermediate between the extremes, but considerably nearer the darker, which occupied the greater area in each case. The colour of the specimens from Loch Heron, paler than

that of those from Cran Loch, certainly looks as though it may be due to difference in acidity, and it may be that this factor can have a subsidiary effect, but the colour-standard of Loch Heron had to be estimated under adverse conditions and may not be quite as accurate as the others. If it be considered that such habitats as harboured *Glaenocoris* do not provide quite conclusive evidence on which a comparison between the effects of these two factors, acidity and colour of background, can be made, an example will be quoted involving another species of Corixid, already mentioned in connection with acidity, namely *Corixa concinna*. This species was found, among other localities, in two interesting ones in which the relation between acidity and colour of background was abnormal; for in one (a pond) the water was acid but the bottom was pale, while in the other (a peaty loch) the water was about neutral but the bottom was dark: the colour shown by *C. concinna* in these two localities is shown in Table 2, and it is seen to agree with colour of background rather than with acidity. This is normally a rather pale species in my experience; and to find such dark specimens as those from the peaty loch is unusual, but it is also unusual to find the species over such a dark background.

TABLE 2.

Showing colour of *Corixa concinna* Fieber and its relation to acidity, and to the colour of the background.

Habitat	Colour of background	pH	Colour of insects						
			g-h	h	h-i	i	i-l	l	l-m
Silt-pond near Kirkcudbright Peaty loch on Lochar Moss	h	6.5	4	6	1	1			
	n-o	8.0-10.0					1	3	1

Why, then, if acidity is not itself the primary cause of colour, is there in the majority of cases a rough correlation between acidity and colour of CORIXIDÆ? The reason is undoubtedly that, in most (not all) water-bodies there is a correlation between colour and acidity, the colour becoming darker as the acidity rises; and the colour of the background directly determines that of the CORIXIDÆ. In short, then, one can state that the degree of pigmentation is directly proportional to the colour of the background in all cases, and indirectly proportional to the pH value in most cases, the colour being the direct factor, and the pH (since there is likelihood that the acidity or alkalinity of the water plays a part in determining the nature of the bottom) an indirect one.

Summary and Conclusions.

1. There has been a tendency in the past to regard European *Glaenocoris* as composed as two geographical forms of one species, a northern dark form and a southern pale one; the former inhabiting particularly the Scottish Highlands and Western Isles in Britain, and the latter being represented in the few southern English localities from which the insect has been recorded. These two forms have been given subspecific rank, and are listed by China (1943) as *G. propinqua* (Fieber) (pale form) and *G. propinqua cavifrons* Thomson (dark form).

2. In south-west Scotland (*i.e.* an area roughly at the junction between those regarded as the respective ranges of the dark and pale forms), I have found *Glaenocoris*a in 10 habitats; in character they were not all intermediate, nor all of the dark form, nor all of the pale, as might have been expected, but extreme dark and pale forms were found, with more or less of a complete gradation between. Moreover, in any one habitat all specimens were found to agree with one another very closely, although they might differ considerably from those in another habitat not far distant. It appeared, therefore, that some physico-chemical or other environmental factor was at work determining in each habitat the form taken by *Glaenocoris*a.

3. Analysis of available data shows that colour-tone of the background over which the insects live is the main factor responsible for determining the colour of the insects. This conclusion agrees with what Dr. E. J. Popham has found in other species of CORIXIDAE. The fact that southern specimens of *Glaenocoris*a are predominantly pale and northern ones dark is probably due merely to the fact that on the whole there are more aquatic habitats with pale bottoms in the south, and more with dark bottoms in the north; this rule is not inviolate, neither is the general rule for distribution of colour-forms in the insect.

4. The difference between the "subspecies" *cavifrons* and *propinqua* rests merely on colour, which is at best flimsy evidence on which to separate subspecies (if indeed such an unsatisfactory taxonomic unit is to be admitted at all). No structural differences have been detected, and there is, in fact, no more justification in regarding the extreme forms as subspecies than there would be in admitting dark and pale forms of, for instance, *Corixa distincta* as subspecies, for the range of colour in *Glaenocoris*a is little greater than in that species, and the variation is equally continuous and depends upon the same causal factor. If the views put forward in this paper are accepted, then it is clear that one must accept but one British species of *Glaenocoris*a, namely *G. propinqua* (Fieber) (which China has shown to be the correct name by the law of priority), and merely refer to dark and pale forms of that species; it is preferable in this case not to use the word "race," which would imply that they are geographically isolated from each other, whereas in actual fact the variation does not depend on geographical range, but upon local factors found within each aquatic habitat.

5. There is evidently no necessity for the explanation put forward by Hutchinson that the dark form entered Britain in the north and the pale form in the south, and that intermediate forms arise through their interbreeding where their ranges have overlapped; for any colour-form may be produced anywhere, merely as the phenotypic effect of local environmental factors; if the variation is to be regarded as a "cline," then it is not a large-scale north to south one, but a local one, dependent upon graded differences in habitat-type.

Acknowledgements.

I would like to express my thanks to Mr. W. E. China for reading this paper in manuscript, and to Lieut.-Col. C. C. Champion for his skilful execution of the photographs on Plate I; also to Mr. H. G. Morgan and Mr. E. Bullock for sending me for comparison specimens of *G. propinqua* from Dartmoor and S.W. Ireland respectively.

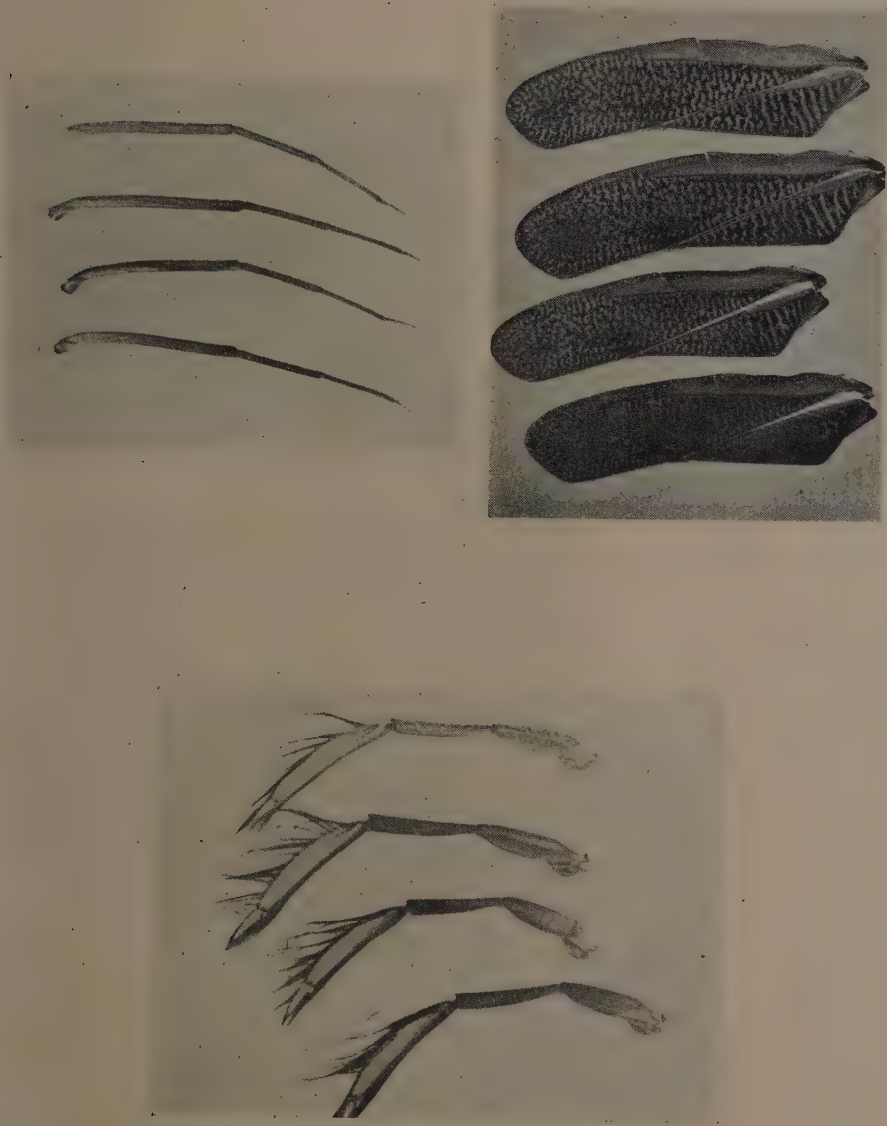
LIST OF REFERENCES.

- CHINA, W. E., 1943, The Generic Names of the British Hemiptera-Heteroptera, with a check-list of the British Species. *R. ent. Soc. Lond. Gen. Names Brit. Ins.* Pt. 8.
- HUTCHINSON, G. E., 1928, Notes on Westmorland CORIXIDAE. *Ent. mon. Mag.* 14: 13-14.
- , 1923-4, Contributions towards a list of the Insect-Fauna of the South Ebrides. IV. The Hemiptera (Rhynchota). *Scot. Nat.* 43-4: 185-91; 45: 21-7.
- HUXLEY, J. S., 1942, *Evolution: the Modern Synthesis*. London.
- JACZEWSKI, T., 1924, Revision of the Polish CORIXIDAE. *Ann. zool. Mus. Polon. Hist. nat.* 3: 1-98.
- POPHAM, E. J., 1941, The variation in the colour of certain species of *Arctocoris* (Hemiptera, CORIXIDAE) and its significance. *Proc. zool. Soc. Lond.* 111 (A): 135-72.
- , 1943, Ecological studies of the commoner species of British CORIXIDAE. *J. anim. Ecol.* 12: 124-36.

EXPLANATION OF PLATE I.

(a) Hemelytra, (b) middle legs, and (c) hind legs of specimens of *Glaenocoris propinqua*.

In each case, from the top downwards, the specimens are from Branxholme Wester Loch (Roxburgh), Troston Loch (Kirkcudbright), Priddy Pool (North Somerset), and Cran Loch (Dumfries). Photos by C. C. Champion.



Hemelytra, middle and hind legs of *G. propinqua* Fieber.

Eu. 344

Vol. 96. Part 2. Pp. 11-46, 1 pl., 13 figs.

April 15th, 1946.

THE
TRANSACTIONS
OF THE
ROYAL
ENTOMOLOGICAL SOCIETY
OF
LONDON

World List abbreviation: Trans. R. ent. Soc. Lond.

CONTENTS

FRASER, Lt.-Col. F. C., I.M.S. Retd., F.R.E.S.

Notes on Amazonian Odonata in the Leeds

Museum

PAGE

11-46, 1 pl., 13 figs.

LONDON:

PUBLISHED BY THE SOCIETY AND

SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 10s. 0d.

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Founded, 1833. Incorporated by Royal Charter, 1885.

PATRON—HIS MAJESTY THE KING.

OFFICERS and COUNCIL for the SESSION, 1946-1947.

PROF. G. D. HALE CARPENTER, M.B.E., D.M., *President*.

W. J. HALL, D.Sc.
C. B. WILLIAMS, M.A., D.Sc. } *Vice-Presidents*.
H. B. WILLIAMS, LL.D.

A. WELTI, *Treasurer*.

N. D. RILEY, *Secretary*.

Other Members of Council.

C. H. ANDREWES, F.R.S.

J. W. EVANS, M.A., D.Sc.

G. FOX-WILSON, N.D.H.

R. M. GREENSLADE.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

CAPT. R. A. JACKSON, R.N.

MISS C. E. LONGFIELD.

SIR GUY A. K. MARSHALL, K.C.M.G.,

D.Sc., F.R.S.

G. E. J. NIXON, B.A.

J. F. PERKINS, B.Sc.

F. J. GRIFFIN, A.L.A., *Registrar*.

Finance and House Committee.

G. FOX-WILSON, N.D.H. (*Chairman*).

J. W. EVANS, M.A., D.Sc.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

W. RAIT-SMITH.

O. W. RICHARDS, M.A., D.Sc.

Publication and Library Committee.

W. J. HALL, D.Sc. (*Chairman*).

H. E. HINTON, B.Sc., Ph.D.

B. M. HOBBY, M.A., D.Phil.

J. F. PERKINS, B.Sc.

J. SMART, B.Sc., Ph.D.

W. H. THORPE, M.A., Sc.D.

Committee on Generic Nomenclature.

FRANCIS HEMMING, C.M.G., C.B.E. (*Chairman*).

W. A. F. BALFOUR-BROWNE, F.R.S.E.

K. G. BLAIR, D.Sc.

O. W. RICHARDS, M.A., D.Sc.

N. D. RILEY (*Secretary*).

Committee for the Protection of British Insects.

H. M. EDELSTEN, O.B.E. (*Chairman*).

R. B. BENSON, M.A.

E. A. COCKAYNE, M.A., M.D., F.R.C.P.

CAPT. R. A. JACKSON, R.N.

COL. F. A. LABOUCHERE.

A. M. MASSEE, D.Sc.

THE HON. MIRIAM ROTHSCHILD.

W. H. THORPE, M.A., Sc.D.

N. D. RILEY (*Secretary*).

The Executive Officers of the Society are *ex-officio* members of all Committees.

DELEGATES OF THE SOCIETY TO :

1. British National Committee for Biology (Royal Society).

Sir Guy A. K. Marshall, K.C.M.G., D.Sc., F.R.S., appointed 1939.

Dr. V. B. Wigglesworth, M.A., B.Ch., M.D., F.R.S., appointed 1943.

2. Local Committee of Management of Wicken Fen.

Mr. H. M. Edelsten, O.B.E. [nominated by Committee for the Protection of British Insects].

3. National Trust for Places of Historic Interest or Natural Beauty.

Mr. H. M. Edelsten, O.B.E., appointed 1944.

4. New Forest Association.

Mr. W. Fassnidge, appointed 1934.

5. New Forest Joint Committee.

Mr. W. Fassnidge, appointed 1939. Dr. F. J. Killington, D.Sc., A.L.S., appointed 1939.

6. Royal Meteorological Society. Phenological Committee.

Dr. C. B. Williams, M.A., D.Sc., appointed 1937.

7. Biology War Committee.

Prof. P. A. Buxton, M.A., F.R.S., appointed 1941.

8. Council for the Promotion of Field Studies.

Dr. W. H. Thorpe, M.A., Sc.D., appointed 1944.

9. Joint Bioclimatic Committee.

Dr. B. P. Uvarov, C.M.G., D.Sc., appointed 1945.

Dr. C. B. Williams, M.A., D.Sc., appointed 1945.

NOTES ON AMAZONIAN ODONATA IN THE LEEDS MUSEUM

By Lt.-Col. F. C. FRASER, I.M.S. Retd., F.R.E.S.

Manuscript received 5 December, 1944.

(Read 2nd May, 1945.)

WITH 1 PLATE AND 13 TEXT-FIGURES.

THIS paper is a continuation of a series which was initiated by Mr. W. D. Hincks (1934, *Ent. Rec.* 46 : 77) and was intended to deal with a large collection of Odonata from Peru and Colombia which he then possessed but which he has since generously presented to the Leeds Museum. The material was collected in the regions of the upper waters of the Amazons in the following localities :— (1) PERU : Iquitos and Mishuayacu near Iquitos ; (2) N.E. PERU : S. Antonio, Yumbatos and Balsapuerto in the valley of the Rio Huallaga, and (3) COLOMBIA : Umbria and Florida in the valley of the Upper Putumayo river. The Huallaga rises in the Andes, runs northwards along the foot of the hills for some 500 miles and then turns eastwards to become one of the main tributaries of the Amazon : the Putumayo rises in the Ecuadorian extension of the Andes and runs eastwards to form the boundary between Colombia and Peru, eventually entering Brazil to join the Amazon at a point much farther to the east than the Huallaga. Between these two rivers, Ecuador is sandwiched and contributes many rivers which empty into the Huallaga and Amazon : thus the fauna of this water-system may be said to be common to Peru, Ecuador and Colombia. Dr. C. H. Kennedy of Columbus University is at present working on the Ecuadorian Odonata, of which he possesses an enormous amount of new material, and I have been in communication with him to avoid any possible overlapping of descriptions of new species.

To entomological students, much of the Andean region remains terra incognita ; collecting therein has been very sporadic, the incessant rains and fitful sunshine affording very few suitable or favourable collecting days, and therefore militating against making it a paying proposition for the professional collector. Thus the classification and our knowledge of the fauna still remain in a chaotic condition and may well continue to do so until the specialist is able to study it first hand on the spot. This applies especially to some groups in which the multiplicity of very similar forms renders it difficult or impossible to determine whether one is dealing with separate species, subspecies, races or even mere varieties. The POLYTHORIDAE, which form the special subject of this paper, come into this category and in their puzzling variety of forms offer an exact parallel to the Oriental genus *Mnais*.

Mr. Hincks' first paper dealt exclusively with the family AESHNIDAE : a second short paper by myself, published in 1943 (*Proc. R. ent. Soc. Lond.* (B) 12 : 161), described the only specimen belonging to the family GOMPHIDAE present in the collection. In the present paper, which represents the third of the series, species belonging to the families POLYTHORIDAE, HETAERINIDAE and COENAGRINIDAE are dealt with, including some in my own collection which were given me some years ago by the late Mr. Morton. I take this opportunity of thanking Mr. Hincks and the authorities of the Leeds Museum for delegating to me the task

of reporting on this important collection, and also to acknowledge Dr. Hobby's kindness in searching for the type of *Polythore picta* (Rambur) in the Hope Museum and for the photograph of it. This specimen forms the foundation-stone of the *picta* group and it would have been difficult to work without it.

Order Odonata.

Suborder Zygoptera.

Superfamily Agrioidea Till.

Family POLYTHORIDÆ Till. & Fras.

The family POLYTHORIDÆ is distinguished from all others in the Order Odonata by the suppression of the arculus and of the proximal primary antenodal: in only one genus is the latter present and then only in a very atrophied condition (*Euthore* Selys). The extension of the base of the discoidal cell forward to meet the primary distal antenodal has led to the absorption of the upper part of the arculus and, at the same time, to a hypertrophy of that antenodal as a response to the greater strain thrown upon it. The POLYTHORIDÆ undoubtedly, at one time, possessed both primary antenodals as in all the more primitive families, for their presence in the genus *Euthore* fully substantiates this. It might justly be expected to find these two antenodals in the more simply veined and therefore more archaic members of the family, so that it is a matter for surprise to find only the distal one present. I felt so sure of this that I actually expressed the opinion that Calvert had overlooked the weak proximal primary when describing his new genus *Miocora*; however, Dr. Calvert has since informed me that he has re-examined the type and finds that there is only one primary, the distal one, present. I have gone further into this matter under the discussion of *E. modesta* (Selys) below.

The family contains nine genera, which I give here in their probable evolutionary order:—*Protophore* Cock. (Eocene), *Euthore* Selys, *Stenocora* Kennedy, *Miocora* Calvert, *Kalocora* Kennedy, *Josocora* Kennedy, *Cora* Selys, *Chalcopteryx* Selys and *Polythore* Calvert. Kennedy, in discussing his genus *Stenocora* (1940, *Ann. ent. Soc. Amer.* 33: 435), theorises that the genotype *percornuta* Kennedy, is a very primitive insect, and likens it to a living fossil from before the Eocene. He has, however, failed to appreciate the importance of the absent proximal primary antenodal, which fact alone places it as a more recent insect than any species of *Euthore*, which latter can hardly be regarded as "living fossils." Moreover the high specialisation reached in other items of its anatomy rather suggests that the simple venation met with in *Stenocora* is a secondary and recent development, probably being a response to the small size and therefore lighter weight of the insect, to which Kennedy himself was the first to draw attention.

Genus *Polythore* Calvert.

The whole of the representatives of the family found in the Leeds' Museum collection belong to the genus *Polythore* Calvert. It is a difficult genus owing to the multiplicity of very similar forms, and, in this respect, parallels closely the genus *Mnais* Selys in Asia, and to a less extent, the palaearctic *Agrion* (*Calopteryx* Selys). So bewildering are many of these forms in their similarity that it is difficult or often impossible to determine whether one is dealing with varieties, subspecies or even species. In the case of the series before me I notice that

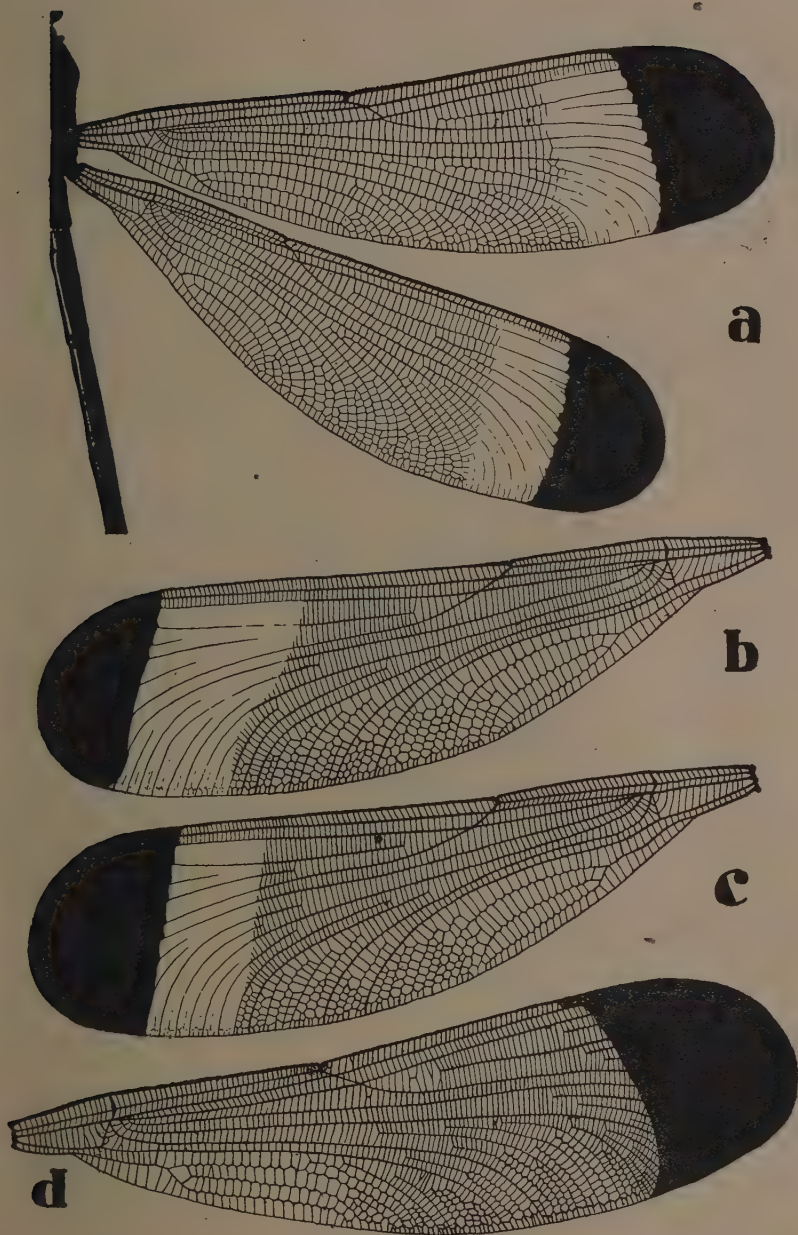


FIG. 1.—a. Fore- and hind-wings of *Polythore derivata* (McLachlan), type male in the British Museum. b. Hind-wing of *Polythore derivata* race *originata* n., male. c. Hind-wing of *Polythore derivata* race *adjuncta* n., male. d. Fore-wing of *Polythore derivata* race *terminata* n., male.

specimens from any one locality resemble one another so closely that, after studying them for a time, I was able to determine their correct habitat without a single error, and yet they are so nondescript that I find it a matter of difficulty to give the points in which each series differs from the others. I had hoped that the genitalia might throw some light on this difficult problem, but an examination of the penes of the *picta* group of forms shows that all agree with Kennedy's figure of *P. gigantea* (Selys). The non-availability of types has added to the difficulties of determination, and this same difficulty, in the past, has led to a large number of synonyms. Dr. Ris, faced with this difficulty in the case of the type of *picta* Rambur, went to the extraordinary length of suppressing this name in favour of *procera* Selys on the grounds that—"one at least knew what one was talking about in the case of the latter," and this in spite of the fact that the name *picta* had priority of eleven years and its type was known to repose in the Hope Museum, Oxford. I have been more fortunate in this respect as Dr. Hobby has kindly searched for and found the type of *picta*, and obliged me with a photograph of the insect, which illustrates this paper. With the aid of this, I have been able to split the *picta* group of forms into those in which the black apical marking has a comparatively blurred or indeterminate ending proximally, and those in which this same border is clear-cut and sharply defined. Under *picta* I include *picta*, *procera* and *gigantea*, whilst under the heading of *derivata* McL., I include *derivata* and four new forms. A study of these groups convinces me that the trend of evolution is towards two definite species, one in which the whole of the wings are black, a common type of marking in the family AGRIDAE; and one in which only the apices of the wings are tipped with well-defined black, a type of marking which crops up continually throughout the Order Odonata, not only in genera, but also in families and in the suborders. In the case of the *derivata* group of forms, this evolutionary trend has been practically attained, but in the *picta* group it is still in its infancy. It is of interest to note in this latter series that polymorphic, andro- and hetero-morphic forms of the females occur only in the annectant forms, which may indicate that the extreme ends of the series are becoming crystallised into two definite species.

Group *picta*.

Polythore picta (Rambur).

- Euthaea picta* Rambur, 1842, *Ins. Nèvrop.* : 231.
Thore picta Selys, 1853, *Syn. Cal.* : 70.
Thore saundersii Selys, 1853, *loc. cit.* : 70.
Thore picta Selys, 1854, *Mon. Cal.* : 256.
Thore picta Hagen, 1869, *Stettin. ent. Ztg* 30 : 257.
Thore procera Selys, 1869, *Bull. Acad. Belg.* 27 (2) : 671.
Thore procera Selys, 1873, *Bull. Acad. Belg.* 35 (2) : 498.
Thore picta race *picturata* Selys, 1873, *loc. cit.* 35 : 499.
Thore saundersii Selys, 1873, *loc. cit.* 35 : 500.
Thore procera Kirby, 1890, *Cat. Odon.* : 116.
Thore picta Kirby, 1890, *loc. cit.* : 116.
Thore picturata Kirby, 1890, *loc. cit.* : 116.
Thore saundersii Kirby, 1890, *loc. cit.* : 117.
Thore procera Ris, 1918, *Archiv für Nat.* 82(A) (9) : 34.

Male. Abdomen 37-54 mm. Hind-wing 34-50 mm.

Female. Abdomen 35-41 mm. Hind-wing 37-45 mm.

The type of *picta* in the Hope Museum bears three labels—the original "*Euphaea picta* R.", a second—"Cayenne", and a third in an unknown hand, in

pencil—" *Thore saundersii* Selys". The apical marking of the fore-wing covers rather more than one-third the wing length and its border is sigmoidal and distinctly vignetted off into the opalescent adjacent area, which latter deepens in intensity near the costal margin and up to half-way from the dark area to the nodus (shown in the photograph as a roughly wedge-shaped black patch). I have three males and three females received from Mr. Morton and all determined by him as *Thore procera*. In two of the males the measurements are—abdomen 54 mm., hind-wing 47 mm.; whilst the third is smaller: abdomen 50 mm., hind-wing 43 mm. In one of the larger males and in the small one, the apical marking differs very slightly from the type of *picta*, whilst the opalescent area is variable, extending generally proximal to the nodus but most intense in the costal and postnodal areas: in one specimen it is arrested sharply at the nodus but continued proximal to that structure in the body of the wing as a wedge-shaped area half-way to the discoidal cell. In the other large male, the dark apical area extends considerably more proximad and covers roughly about half the wing. The colour appears to intensify with age, becoming dark blackish-brown in full adults and with a steely blue, violaceous or even bluish-green iridescence. In the form of *picta* named by Selys as *procera*, the apical dark area may extend right up to the level of the nodus but not beyond that level. It is possible, however, that forms may come to light in which this level is overshot and which, therefore, approach and merge into *gigantea* Selys. In the andromorph female, the measurements are—abdomen 38 mm., hind-wing 37 mm., and the dark area is similar to that of the males, extending, however, right up to the level of the nodus: *there is no apical hyaline area* as in the conventional female belonging to this group. The heteromorph females are slightly larger and have an apical hyaline area extending to just proximal of the pterostigma, the dark band following falling well short of the nodus: the opalescent area proximal to this dark band extends up to the nodus and, posterior to the Radius, as a wedge-shaped area similar to that mentioned for one of the males.

Habitat: COLOMBIA, PERU, ECUADOR and GUIANA. Appears to be found along most of the tributaries of the Upper Amazons. Apart from racial or varietal differences, there is nothing to distinguish *procera* from *picta* and there can be no doubt about the synonymy. In regard to *P. gigantea*, more material will be necessary to settle the identity but at present I am inclined to regard it as a separate species. Selys, after examining the type of *picta* in 1872, came to the conclusion that both *saundersii* and *picturata* were synonymous with *picta*, the two latter both coming from the same habitat—Cayenne. There is no evidence to show that Kirby ever examined the type of *picta* but I have personal evidence that, having quarrelled with McLachlan, he was denied the opportunity of examining the latter's rich material belonging to the POLYTHORIDAE: he therefore took the easy method of cataloguing the whole of the synonyms as separate species.

Polythore gigantea (Selys).

Thore gigantea Selys, 1853, *Syn. Cal.*: 69.

Thore gigantea Selys, 1854, *Mon. Cal.*: 254.

Thore gigantea Selys, 1869, *Bull. Acad. Belg.* 26 (2): 670.

Thore gigantea Kirby, 1890, *Cat. Odon.*: 116.

Thore gigantea Ris, 1918, *Archiv für Nat.* 82(A) (9): 31, 38.

Male. Abdomen 48–50 mm. Hind-wing 40–44 mm.

Female. Abdomen 32–35 mm. Hind-wing 34 mm.

There is a single pair of this fine species in the Leeds collection, both a shade smaller than the type male and allotype female. In the male, the wings are very dark reddish-brown from apex to a level half-way between the nodus and discoidal cell although the area between the costa and radius is hyaline almost up to the pterostigma, as also is the basal portion of the wings. The dark area is not uniform however, for a much darker apical area is seen to be limited by a slightly concave border at a level less than half-way from nodus to pterostigma, after which the dark area becomes abruptly paler and is continued in a tapering manner towards the base of the wings: it strongly suggests that this latter area has developed at a later date than the apical portion and that this same area was originally opalescent white as in the *procera* form of *picta*. In the female, the dark area is more restricted and extends only a short way proximal to the nodus and that only between the veins R and MA: distally it ends at a level of about 6 or 7 costal cells proximal to the pterostigma, the apices being hyaline but palely enfumed and limited by a narrow bordering of dark brown round the apices of wings. In the hind-wing, the hyaline area is much smaller and is limited to a very small patch just below the pterostigma. The dark area is steely purplish-blue metallic and more brilliant than in the male.

Habitat: The type, in the Selysian collection, is from COLOMBIA; the present pair are from PERU, San Antonio, i.33, and were determined by Morton, I consider correctly. Regarding its affinity to *picta*, Selys' words carry great weight—"I am more and more convinced that *T. gigantea* is protean as much in respect to its size as in its colouring of the wings, and that one will find in it all the intermediaries between it, *procera*, *picturata* and *saundersii* (*picta*), so that the general distribution of the species will be Venezuela, Ecuador, Upper Amazons." He added that the indication from Cayenne was very doubtful, although, in the same paper, he gave the habitat for *picturata* as Cayenne.

Polythore victoria (McLach.).

I possess a single male of this species which does not differ in any way from the type. I received it from Morton, who had determined it. Abdomen 53 mm. Hind-wing 48 mm. The type is from BOLIVIA: the present male is from PERU, Pozuzo, 800 m., 2.x.06.

Group *derivata*.

Polythore derivata (McLachlan) (fig. 1, a).

Thore derivata McLach., 1881, *Trans. ent. Soc. Lond.* 1881: 27, Ecuador.

Thore derivata Kirby, 1890, *Cat. Odon.*: 117, Ecuador.

Thore derivata Ris, 1918, *Archiv für Natur.* 82(A) (9): 31, 36, Bolivia (race?).

The type male of *Thore derivata* McLachlan and other males and two females are now in the British Museum (Nat. Hist.) (Reg. No. 1934-674). The type bears the following labels—1. "Type". 2. "*Thore derivata*" (in McLachlan's own handwriting). 3. "R. Bobonaza, Ecuador, Buckley". It is some years now since I saw the McLachlan collection and the necessity for a critical examination of the type of *derivata* had not then arisen: unfortunately the war has prevented me from carrying this out since and, at this lapse of time, I am not able to recall the exact characters of the wing markings, viz., the extent of the black apical band and the preceding white one. McLachlan's descriptions of these are too concise to be of much value when comparisons of

closely similar species are involved: he wrote—"The black terminal portion of the wing commences at about the last fifth of the distance between the nodus and pterostigma, thus occupying less than one-fifth of the entire wing; it is preceded by a milky band *as usual*." Unfortunately these bands vary widely in the different forms and races: the white band may be altogether absent, or if present, then broad or narrow, sharply defined or obscure and fading gradually into the hyaline area of the wing. The apical black marking also may be sharply defined or vignettted into the milky band. Dr. Ris, faced with similar difficulties some twenty-six years ago, took the course of describing two different forms of *derivata*, neither of which turns out to conform to the type. I have been more fortunate in this respect owing to the kindness of Mr. N. D. Riley and Mr. W. H. T. Tams, who have combined to procure for me a photograph of the type now temporarily deposited for safety in the Tring Museum: my thanks are due to both of these specialists, for with the aid of the photograph it is now possible to view the whole of the *picta-derivata* section of the genus *Polythore* in its correct perspective.

The separation of *P. derivata* from *P. picta* was made by McLachlan mainly on account of the great differences between their respective females, that of the former having the usual apical hyaline area of the wings almost obsolete. In summing up the differences, he wrote—" *T. derivata* might be considered as a race of *picta* Rambur (*saundersii* Selys) but the much less extension of the dark area of the wings in the male and the great differences in the female appear to entitle it to specific rank." He does not appear to have examined the type of *picta*, or he may not have refreshed his memory by a re-examination made at the time of describing *derivata*, for he failed to comment on the marked difference between the dark area of *picta* which has the proximal border diffuse and vignettted into the white band, and that of *derivata* in which it is sharply limited, evenly concave and sharply defined from the preceding white band. This difference separates *derivata* from the whole of the *picta* group (*picta-procera* and *gigantea*). In the material from the Leeds Museum are a number of variable forms, in none of which the apical black area agrees entirely with that of typical *derivata*, but in all of which it possesses the same sharply limited and clear-cut character of that species: the white band is variably present or absent, sharply limited or vignettted and of varying breadth. From definite localities come series in which the individuals composing them resemble each other more closely than they do individuals from other localities, so that I prefer to regard them as races rather than varieties of *derivata* to which all are obviously very closely related.

To the McLachlan description of *derivata* may be added the following—Wings of male with markedly rounded apices, all tipped moderately broadly with black and rather more so in the fore-wing than in the hind. This dark area is bordered proximally by an opalescent white band which is well defined, of even width throughout and about two-thirds the width of the black area. The proximal border of the latter is shallowly and somewhat regularly concave and its width bears a ratio to the rest of the wing of 1 to 4.6 and 1 to 4.8 in the fore- and hind-wings respectively. The main nervures traversing the white area, as well as the secondary reticulation, with the exception of the Costa, Radius and Rii, are also white, the change from black to white being quite abrupt. The penis has not been described but it may be assumed that it does not vary from those of the races described below, as these do not vary appreciably from that of *P. gigantea* as figured by Kennedy. In estimating the ratio of the width of the black area to that of the whole wing, measurements have been

taken from the extreme apex of the wing to the mid-point of the proximal border of the black area.

The specimens described by Ris from Pozuzo, Peru, appear to belong to group *picta* rather than to *derivata* as the white band is said to extend to as far as the nodus or even beyond that level, and is diffuse in character; the great width of the black area clearly separates them from typical *derivata*. The females of this series differ from that sex of *derivata* even more than do the males. The three males from Coroico, Bolivia, possess a black apical area which hardly differs from that of *derivata* but the opalescent band is very indistinct in the single teneral specimen described, and altogether absent in the 3 adults: nevertheless I believe that this race belongs to group *derivata*.

Polythore derivata race adjuncta n. (fig. 1 c).

Male. Abdomen 42 mm. Hind-wing 35 mm.

Black marked with yellow exactly similar to the conventional pattern of the group, differing only in minor details—the base of the labium is broadly white: the labrum is black with a triangular spot of yellow on each side: the bases of mandibles, genae and four spots in a square which enclose the vertex are yellow as in the rest of the group. Yellow markings of prothorax and thorax as for the group but the pectus appears to be wholly black, very heavily pruinosed with chalky white. Wings with moderately broad apical black area bordered proximally by a white band of variable width. The black apex bears a ratio to the rest of the wing of 1 to 3.8 and 1 to 4.4 in fore- and hind-wings respectively, that is, rather less than in *derivata*, but the proximal border is quite straight instead of concave and the white band preceding it is only half the breadth of the same band in *derivata*. In one of the adult males, the white band is almost obsolete but otherwise it does not differ from the others.

Female. Abdomen 30–32 mm. Hind-wing 27–33 mm.

Differs but slightly from the female of *derivata* in so far as I am able to tell from the McLachlan description. In the fore-wing the dark apical band begins as in the male as far proximal to the pterostigma as the length of that organ, whilst it ends distally at the outer end of the same structure: in the hind-wing the hyaline area left at its apex is considerably smaller than in the fore-wing and, in some, is a mere linear border to the extreme apex, the cell middles only being clear. A narrow opalescent band precedes the black as in the male and is about the same width as in that sex. The bases of the wings in both sexes are enfumed pale greyish with black venation, contrasting strongly with the white bands.

Habitat: COLOMBIA: Umbria, 2 adult males, 1 teneral and several females, from 10.xi.30 to 10.ii.31. This race lies near *derivata* more closely than do the others in the present material and differs chiefly by the straight border to the black apical area and by the much narrower white band which precedes the latter. Possibly the black labrum may be another difference, as this structure is usually yellow marked with black in the genus *Polythore*. The female differs by the much larger apical hyaline area in the fore-wings, which is nearly obsolete in *derivata*.

Polythore derivata race originata n. (fig. 2, b).

Male. Abdomen 38 mm. Hind-wing 33 mm.

Head, thorax and abdomen black with yellow markings of the conventional Polythorine pattern: labrum entirely yellow save for a small medio-basal spot of black: metepimeron bordered anteriorly and posteriorly with yellow: pectus heavily pruinosed over yellow and

two large black spots which are more or less obscured. Wings with apical sixth to seventh blue-black but with a strong metallic blue reflex when viewed at certain angles: the dark area extending in the fore-wing slightly proximal to the pterostigma but only as far as its proximal end in the hind-wing, its proximal border cleanly-cut and even, but obliquely inclined from costa to termen distalwards. (This apical marking is almost identical to that found in *Vestalis apicalis* Selys.) It is bordered proximally by a very broad and equally sharply defined opalescent white band, the proximal border of which is even more oblique than that of the black area: in the fore-wing it ends half-way from the border of the black area to the nodus, but rather less than this in the hind-wing, in which latter it tapers somewhat to the termen of wing. The remaining basal portion of wings pale greenish-grey with black venation, this latter changing abruptly to white in the opalescent area. Thus the wings are divided up into *three very sharply defined coloured areas*.

Female. Abdomen 32 mm. Hind-wing 34 mm.

Body coloured as in the male but the wings agreeing generally with the conventional colour pattern for females of the *picta* group. The basal parts are coloured exactly as in the male and to a similar extent, but distal to the nodus there is a suffusion of pale brown which gradually deepens to as far as the opal band. The latter is only half the width of the similar band in the male but is equally sharply defined and with white venation. The apical black area is much more extensive, extending in the fore-wing along the costal margin to half-way from apex of wing to nodus and ending distally at inner end of pterostigma, thus leaving a large hyaline apical window which is framed apically by a narrow bordering of dark brown. In the hind-wing the same band as a whole lies more distally, so that its distal border overlaps the pterostigma slightly and the apical hyaline window is reduced to half the size of that of the fore-wing: in both wings the distal and proximal borders of the dark band are deeply concave, thus rendering it hour-glass-shaped.

Habitat: PERU: Mishuyacu (Katzenbach), 15 km., v. Iquitos, 13.iii.31. A single pair, the male the *type*, which will be deposited in the British Museum (Nat. Hist.). This well-defined race differs from *derivata* by the greatly restricted black apical area of the wings, which bears a ratio to the rest of the wing of 1:6 in the fore-wing, and 1:6.7 in the hind. The white opalescent band is also much wider than in *derivata* and tapers posteriorly instead of being of even width: lastly the portion of the wings proximal to the white band is evenly tinted with greenish-grey, which throws the pale band into greater prominence. The dark apical area is more restricted in *originata* than in any other species belonging to the genus, but whether this represents a progressive or retrogressive change it is difficult or impossible to say; I am inclined to think that the change from white to black is progressive since the white areas are always present at the time of the emergence of the imago, whilst the black (or other colours such as orange and red, found in the *concinna* group) develops afterwards over a period which may run into a week or more. In the group *concinna*, at least two species retain the white colour of the bands throughout imaginal life, whilst in all the other known species this same band changes from white to yellow, orange and finally reddish in very adult life: this fact alone goes to prove that the white colouring is a primitive character. An exact parallel is found in the Oriental genus *Mnais*, where the wings of some species are opaque white in part on emergence but change later to a rich orange or amber tint.

Polythore derivata race ambigua n.

Male. Abdomen 37-43 mm. Hind-wing 32-38 mm.

I include under this race a large number of specimens nearly all of which are from Yumbatos, Peru, but which differ from one another in slight details to such

an extent that I find it difficult to define any one as typical of them all. All agree in possessing a broad apical black area to the wings which is broader than that of *derivata* but which is concave along its proximal border as in that species: all too possess a white band which, however, differs markedly between individuals. The breadth of the apical black varies rather widely: in an extreme case it covers nearly one-third of the wing area and extends about half-way from the apex of wing to the nodus. In two other males the black area is narrower, covering about one-fourth of the wing length, and the preceding white band is only one-third of its breadth and very sharply defined as in *adjuncta* (fig. 1, c). The ratio of the black area in the fore-wing to the wing length averages from about 1 to 3.5 to 1 to 4.0. The white band in most specimens is about half the width of the black, but in many specimens the proximal border is not at all clearly defined and may be gradually vignetted to as far as the nodus: in these latter the area is fluorescent bluish by transmitted light. The hyaline basal portion of the wings is greyish or even tinted palely with yellow or pale greenish (aquamarine) and the dark nature of the reticulation in this area throws the white band into sharp relief. I find also considerable diversity in the colour of the labrum, some being yellow, marked and bordered finely with black, whilst others are black with outer triangular spots which may or may not be confluent across the middle line of the lip.

Female. Abdomen 34-37 mm. Hind-wing 31-35 mm.

Differs markedly from the female of *derivata* by the broad apical hyaline area of the wings: the dark band begins almost immediately proximal to the pterostigma and extends inwards from thence to a point about midway between the latter and nodus. The outer border of the band is more or less straight and is continuous with a fine apical bordering of dark brown which encloses the hyaline area: its proximal border is deeply concave and bordered by an opalescent white band as broad as itself.

Habitat: PERU: Yumbatos, x.-xii.32, numerous males and females. Broadly speaking, this race may be said to differ from typical *derivata* by the broader black apical area which is itself bordered by a narrower white band: the female differs more widely by the possession of a very broad hyaline apical area to the wings. Ris's specimens from Coroico, Bolivia, may belong to this heterogeneous series.

Polythore *derivata* race *terminata* n. (fig. 1, d).

Male. Abdomen 46-52 mm. Hind-wing 42-47 mm.

Head, thorax and abdomen black with yellow markings similar to those of *P. picta* (Rambur): labrum black with a large triangular spot on each side; beneath thorax two elongate black streaks in the long axis of thorax but largely concealed beneath dense pruinosity. Wings with a broad black apical area to the apices which is dull bluish-violet or dark green metallic by reflected light and covers slightly less than one-fourth of the wing's length: its ratio to the wing length is 1 to 3.5 in the fore-wings, and 1 to 3.7 in the hind-wings, its proximal border is sharply defined and lies obliquely from costal to posterior border of wing distalwards, but with the extreme costal and posterior ends prolonged along the wing borders for a slight distance. There is no sign of any opalescent white band bordering it proximally in the majority of specimens, and but the slightest trace in the others, in which it fades imperceptibly into the hyaline base of wings. In most specimens, the cells adjacent to the nodus are coloured with fuscous, thus rendering that structure somewhat conspicuous. Anal appendages and penis not differing from those of *P. gigantea*.

Female. Abdomen 37 mm. Hind-wing 37 mm.

Colour and markings similar to those of the male but the yellow spot and stripe on the sides of segments 2 and 3 are repeated on segment 4. Wings coloured and marked very similarly to those of the heteromorphs of *procera* race of *picta* but the black band is much narrower and more constricted at its middle where it is of not greater width than the length of pterostigma: it extends from a point as far proximal of the pterostigma as the length of that organ and ends at a level slightly proximal to midway between nodus and pterostigma: it lies somewhat obliquely to the long axis of wing and is bordered proximally by a narrow opalescent white band of even width throughout but only half the breadth of the black band: this latter is of the same dull metallic blue-black as in the male.

Habitat: N.E. PERU: San Antonio, 7 males and 2 females, xi.-xii.32. This fine race is conspicuous by its large size, by the oblique nature of the black apical marking of the wings and by the absent or obsolete white band common to most other species. The female is differentiated by the markedly constricted "hour-glass" dark band situated far proximally in the wings, thus leaving a very large hyaline window at the apices. *Type* male and allotype female will be deposited in the British Museum (N.H.).

Polythore vittata (Selys).

Thore picta Selys, 1869, *Bull. Acad. Belg.* 27 (2): 672.

Thore picta race *vittata* Selys, 1869, *loc. cit.*: 673.

Thore picta race *aequatorialis* Selys, 1873, *Bull. Acad. Belg.* 35 (2): 500.

Thore albiovittata Selys, 1873, *loc. cit.* 36 (2): 618.

Thore aequatorialis Kirby, 1890, *Cat. Odon.*: 116.

Thore albiovittata Kirby, 1890, *loc. cit.*: 117.

Thore vittata Kirby, 1890, *loc. cit.*: 117.

I have not seen this species, but Dr. Schmidt sent me, a few years ago, the two photographs which illustrate this paper and serve well to show the differences separating it from allied species (Pl. 1, figs. 2, 3). The male resembles the *procera* variety of *picta* but the dark area is traversed by a narrow white band at the junction of the middle and proximal thirds of the space between the nodus and pterostigma: the band extends forwards only as far as Ri or Rii and is ill defined in its posterior portion. In the hind-wing the band is considerably narrower but lies in very much the same position. The female has the same type of marking but the white band is three times as broad as in the male in both fore- and hind-wings: the black apical portion has a broad hyaline window in the fore-wing to as far proximad as the inner end of pterostigma, whilst a similar hyaline area in the hind-wing is half the size and largely obscured by the close network of deep black venation and some enfumation of the membrane.

Habitat: ECUADOR. Ris states that *aequatorialis* Selys, which the author gave as a synonym for *albiovittata* Selys, is the female of *P. victoria* McLachlan, but the female wings figured by Ris are entirely different from the wings figured here (fig. 3) and show only a vestigial black band bordering the white one apically, the whole of the broad apex of the wing being otherwise hyaline. Selys gave the synonymy for *albiovittata* in the Appendix to the 3rd Additions *Syn. Cal.*, and this, brought up to date, is the synonymy given above.

Group *concinna*.

The five species—*Polythore concinna* (McL.), *mutata* (McL.), *aurora* (Selys), *beata* (McL.) and *batesi* (Selys)—form a compact group in which the females, contrary to the general rule found in Odonata, have outstripped the males in

their specialisation and show, by a generalised colour pattern of the wings, that they are all closely related to one another. *P. concinna*, in which the wings of the male are simply tinted and the least specialised, is probably the most archaic; *beata* and *mutata*, in which the opaque bars on the wings of the males retain the chalky-white colouring common to teneral even in the adult state, come next in order, whilst *aurora* and *batesi*, in which the same bars (white in the teneral state) develop rich ochreous or orange colouring when fully adult, are the most highly specialised and recent of the group. This orderly development of colouring in the wings closely parallels what is found in the Asiatic *Euphaea*s and *Dysphaea*s which have sprung from the same ancestry as the POLYTHORIDAE.

Key to Species of Group *concinna*.

Males.

1. Wings evenly tinted but without opaque bands *concinna*.
- Wings tinted or not, opaque bands present at least in the hind-wings 2.
2. Opaque bands present in hind-wings only, chalky-white in colour *beata*.
- Opaque bands present in both fore- and hind-wings 3.
3. Opaque bands chalky-white in colour *mutata*.
- Opaque bands ochreous or orange in colour 4.
4. Band in hind-wing broader than that of fore-wing and extending proximal to level of nodus *aurora*.
- Band in hind-wing narrower than that of fore-wing and not extending as far as level of nodus *batesi*.

Females.

1. Fore-wing without opaque band, hind-wing with chalky-white band in tene-
rals, dark ochreous in the adults *beata*.
- Both fore- and hind-wings with opaque bands 2.
2. Band in fore-wing very narrow and with crenulate borders: band in hind-
wing strongly convex distally, tapering posteriorly and curved scythe-like
concinna.
- Bands variable in width in the wings, usually broader and never curved in the
hind-wing 3.
3. Band in fore-wing of adults rich ochreous, that of the hind-wing dusky
violaceous brown and not noticeably bordered distally with dark brown
mutata.
- Bands bordered broadly distally with dark brown 4.
4. The dark brown bordering extending right up to apex of wing *batesi*.
- The dark brown bordering narrower and ending well short of the apex of
wings *aurora*.

Polythore concinna (McLachlan).

Thore concinna McL., 1881, *Trans. ent. Soc. Lond.* 1881 : 29.
Thore concinna Kirby, 1890, *Cat. Odon.* : 117.

The original descriptions were not complete, especially in regard to the colours of the wings. As in the original series, considerable variation in the size of the males is found—abdomen 33 to 40 mm., hind-wing 27 to 34 mm. McLachlan failed to remark on the great breadth of the wings in this sex, a character which, in itself, differentiates them from all others in the group: they are at least half as broad again as in the females and nearly as much so as in the males of other related species. The apices are very broadly rounded and the apical third is distinctly enfumed and darker than the rest of the wing; the

costal border from the base of wing to as far as the pterostigma is broadly bordered with dark amber, whilst the rest of the wing is hyaline and paler. In teneral the wings of the male are uniformly tinted pale amber, which darkens later on in the adult when a fiery iridescence develops comparable somewhat with that seen in the male of the Asiatic *Rhinocypha ignipennis* Selys. In the female, the opaque bands in the fore-wings are very narrow, with crenulate proximal border and fall short of both costal and posterior borders of the wings: in the hind-wings these bands are slightly broader, taper behind and have the distal border markedly convex. The bands in both wings are bordered outwardly by an equally narrow hyaline pale fascia, and this again by a narrow fascia of blackish-brown. Finally the extreme posterior border of the wings as well as the apical border are finely lined with blackish-brown. In the teneral female, all these bands are preceded by a single narrow opaque white one, the rest of the wing being palely fuliginous.

Habitat: The type is from ECUADOR and forms part of the McLachlan collection in the British Museum. Both sexes are represented in the Leeds collection, all from COLOMBIA: Umbria, from 10.xi.30 to 10.i.31.

Polythore aurora (Selys).

Thore aurora Selys, 1879, *Bull. Acad. Belg.* 47 (2): 401.

Thore aurora Kirby, 1890, *Cat. Odon.*: 117.

The Leeds Museum collection contains examples of both sexes of this beautiful species, some of which are adult, some teneral, the latter having the opaque bands on the wings a chalky-white. The description of the male needs amplifying as no mention was made by Selys of the broad dark brown band which borders the opaque yellow ones distally, and which in *batesi* Selys extends over the whole apical area beyond the latter band. This in the fore-wings of *aurora* ends diffusely midway between the nodus and pterostigma, but in the hind-wing pales very gradually to as far as the pterostigma itself. In the female wings this same brown band is much narrower and more sharply defined, as broad as the opaque band in the fore-wings but rather narrower than that band in the hind-wings. In the very adult male, the pale parts of the wings are evenly tinted with pale amber, whilst the whole of the wing is fuliginous by reflected light very much as in *concinna*. The present examples do not differ markedly from the type, but I notice some variation in the breadth of the opaque yellow bands, which in the type extend to the 5th or 6th postnodal at the costal border: in some of the present specimens this band extends to as far as the 10th or 12th postnodal.

Habitat: The type is from ECUADOR: Rio Napo: the new material from PERU: Mishuyacu, from 7.ii.31 to 7.xi.31, viz., for every month of the year excluding December and January.

Polythore beata (McLach.).

Thore beata McLach., 1869, *Ent. mon. Mag.* 6: 28.

Thore beata Selys, 1869, *Bull. Acad. Belg.* 27 (2): 674.

Thore beata Kirby, 1890, *Cat. Odon.*: 117.

A single pair in my own collection, ex Morton collection, agree entirely with the original description of the teneral state. The adult female has been described and differs from the teneral by the opaque white band, which is present in the hind-wing only, becoming dark ochreous; this band, in the adult male, probably retains its primitive white colouring as in *mutata*.

Habitat : Type from PERU : Pebas, Upper Amazons. These new examples are from the same country, Loneto on the Rio Ampiyaca, vi.-vii.23. It has not been possible to examine the rest of Morton's material stored away in the vaults of the Royal Scottish Museum, Edinburgh, but the possible existence of adult males in this collection should not be forgotten.

Polythore mutata (McLach.).

Thore mutata McLach., 1881, *Trans. ent. Soc. Lond.* 1881 : 29.

Thore mutata Kirby, 1890, *Cat. Odon.* : 117.

Of the large amount of material belonging to this species, I have been able to examine 17 males and 6 females, nearly all of which are full adults, and all males of which still retain the chalky-white colouring of the opaque bands on the fore- and hind-wings, so that I do not think any further doubt lingers as to this colour being retained even in full adult age. The retention of the primitive colouring in the male sex only is clear proof of the females far outstripping them in specialisation, a rare occurrence in the Order Odonata but an established rule in this genus. It is of interest to note that the veins, as they pass through the white area of the membrane, share in this colour, becoming abruptly black distally and proximally of this area. The width of the white bands varies somewhat, extending distally to the 7th or as far as the 16th postnodal : unlike *beata*, in which the band extends right up to the costal border, this is arrested in *mutata* at the level of the Radius proximal to the nodus. In the female, the white band of the fore-wing is the first to undergo colour changes, becoming primrose-yellow in the full adult : the band in the hind-wing first becomes ashy white and later violaceous grey. There is considerable variation in the width of these bands, that of the fore-wing usually narrower than in the hind-wing, but, in one specimen at least, the band of the fore-wing is the broadest.

Habitat : Type from ECUADOR : Rio Bobonaza ; the new material in the Leeds Museum is from COLOMBIA : Umbria, 10.xi.30 to 18.ii.31, a comparatively short season.

Euthore modesta (Selys).

Cora modesta Selys, 1869, *Bull. Acad. Belg.* 27 (2) : 680.

Cora modesta Selys, 1873, *Bull. Acad. Belg.* 35 (2) : 504.

Cora terminalis McLach., 1878, *Trans. ent. Soc. Lond.* 1878 : 92.

Cora terminalis Selys, 1879, *Bull. Acad. Belg.* 47 (2) : 407.

Cora terminalis Kirby, 1890, *Cat. Odon.* : 118.

Cora modesta Kirby, 1890, *Cat. Odon.* : 118.

Cora terminalis race *bogotensis* Först., 1914, *Archiv für Natur.* 80(A) (2) : 60.

Cora modesta forma *Ris*, 1918, *Archiv für Natur.* 82(A) (9) : 22, pl. 1, fig. 9.

I possess four males and a single female of this species, which were sent to me several years ago by Mr. Morton and determined by him as *Cora modesta* Selys, although, from their large size and wing markings, they answer better to the description of *Cora terminalis* McLachlan. Morton was probably influenced in giving this determination by the arguments advanced in Dr. Ris's paper quoted above, in which he came to the conclusion that specific distinction between *C. modesta* and *terminalis* was improbable, and that such differences as existed were racial in character or due to teneral uncoloured wings. The present specimens, which came from Pozuzo, Peru, appear to bridge any gaps caused by differences between these two species and establish the synonymy without doubt. The available data are as follows :—

1. Type of *Cora modesta* Selys, a small teneral female with wings unmarked at apices. Abdomen 28 mm. Hind-wing 23 mm. Habitat: COLOMBIA: Bogota.
2. Supposed male of *C. modesta* Selys (age not stated), wings unmarked at apices. Abdomen 31 mm. Hind-wing 26 mm. Same habitat.
3. Type of *Cora terminalis* McLach., an adult male with blackish apical wing markings. Abdomen 40 mm. Hind-wing 35 mm. Female without wing markings: abdomen ? (missing in part), hind-wing 34 mm. Habitat: BOLIVIA.
4. Type of *terminalis* race *bogotensis* Förster, a male similar to *C. terminalis* McL., in size and with apical wing markings. Habitat: COLOMBIA: Bogota.
5. Type of forma *modesta* Ris, adult male with apical wing markings present. Abdomen 30 mm. Hind-wing 24 mm. Females: adult with apical wing markings present, and teneral without such markings. Abdomen 30 mm. Hind-wing 28.5 mm. Habitat: COLOMBIA. Adults have a small scintillating iridescent spot in the postanal area of hind-wings.
6. The present specimens before me, all adult and all, save the female, with dark apical wing markings similar to that shown in Pl. 1, fig. 9, of Ris's paper cited above. Male. Abdomen 40 mm. Hind-wing 35 mm. Female. Abdomen 30 mm. Hind-wing 35 mm. Habitat: PERU, Pozuzo.

It is clear that *modesta* is rather variable in size and that the wing markings are only developed in the adult stage. Probably the female has two forms, a heteromorph with wings completely hyaline, the usual or common form, and an andromorph with wings marked in the adult stage like those of the male.

Whilst examining this new material, an important discovery was made, for it was found that in addition to the distal primary antenodal, which exists alone throughout the family POLYTHORIDAE, except in the genus *Euthore*, a second, the proximal primary, was present. This antenodal in *modesta* is very weak but always present and situated at the 3rd to 5th antenodal proximal to the distal primary. In the female before me, it is at the 3rd in all wings, and is similarly situated for the greater number of male wings which I have to examine. In Dr. Ris's photograph, the proximal primary is seen to be at the 5th in both wings as in 6 of the wings before me. From this it is clear that *modesta* belongs to the genus *Euthore* and not *Cora* and serves to explain also the anomaly of the colouring of the basal segments of the abdomen, which differ from all other species of *Cora* but approach that of *Polythore* and *Euthore*.

In a footnote to the "Reclassification of the Order Odonata" (Tillyard & Fraser, 1938, *Australian Zoologist* 9: 208) I expressed doubt as to the correctness of Dr. Calvert's assertion that his genus *Miocora* possessed only one primary antenodal. I came to this conclusion because the venation of the genus appeared to be so primitive in character that I found it difficult to believe that its evolutionary level was so far advanced that the proximal primary antenodal had become obsolete. Moreover, in *Euthore*, the proximal primary is so weak and inconspicuous that it might easily be overlooked, and, as seen from the above, was actually overlooked in the case of *modesta* by four successive specialists in the Order. Dr. Calvert has kindly re-examined the type again and now informs me that there is no suggestion of a second primary antenodal: this was later corroborated by Dr. Kennedy in his paper "The *Miocora*-like Dragonflies from Ecuador" (1940, *Ann. ent. Soc. Amer.* 33: 406), in which he described new species and genera belonging to or closely related to *Miocora*, in all of

which there was only a single primary antenodal present. Faced with such anomalies in the venation, it becomes necessary to revise existing ideas on the classification of the POLYTHORIDAE. *Protothore* Cockerell, from the Eocene of California, is no doubt the most archaic genus in the family: its simple venation, resembling in some respects that of *Euthore*, its elongated and strongly braced pterostigma and the position of the nodus, which fortunately it is possible to locate exactly in relation to the pterostigma, all suggest the presence of two normal primary antenodals (the base of the fossil specimen is missing, so that it is impossible to be certain of this). The genus *Euthore*, with both primaries present, comes next and is probably followed by the *Miocora* complex—*Stenocora*, *Kalocora* and *Miocora* all with simple unbranched Anal vein. *Josocora*, in which the Anal vein is bifurcated or forked, follows, with *Cora*, *Polythore* and *Chalcopteryx*, in all of which the Anal vein is triradiate, ending the series as the most recent genera. Of the origin of this family, I think there can be little doubt, for the similarity of the thoracic pattern and the morphology of the nymphs with their abdominal anchoring appendages (incorrectly regarded as gills) both point strongly to an Epallagine ancestor. The EPALLAGIDAE represent in Asia the POLYTHORIDAE of America, the two families probably having arisen from a common stem (the distribution being, as Cockerell suggests, by way of N. America) in the Upper Jurassic.

Family HETAERINIDAE Tillyard & Fraser.

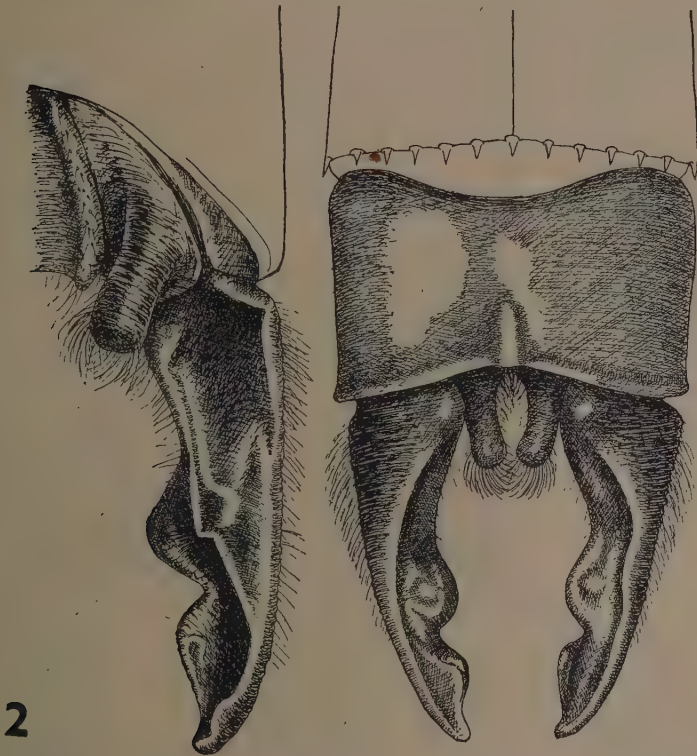
Genus *Mnesarte* Cowley.

Mnesarte hincksi sp. n. (text-fig. 2).

Male. Abdomen 42 mm. Hind-wing 25 mm. (Female unknown.)

Head: labium dull black, genae glossy black, labrum and rest of head velvety black including beneath eyes and occiput: epistome with a slight violaceous metallic reflex. Prothorax with posterior lobe tumid, projecting prominently backwards at its middle, black with the lower part of middle lobe, as well as the coxae and trochanters pruinosed white. Thorax steely blue-black with the lateral sutures and a vestigial humeral stripe, which is deficient below and above, narrowly creamy white, this colour also encircling the metepimeron. Beneath thorax, as well as the ventrum of the first two abdominal segments, clothed with short dense greyish-white hairs. Legs very long, very slim, black: hind femora extending to middle of second abdominal segment, spines closely spaced, fine, of moderate length. Wings narrow, hyaline, unmarked except for a small pale brownish-black mark at apex of hind-wings; venation black; pterostigma absent in all wings; 28-29 antenodals and 25 postnodals in all wings: discoidal cells traversed by 5-7 veins, median space by 6-8, postcostal space by 14-16: 2 rows of regular cells posterior to the anal vein beyond level of discoidal cell. Abdomen steely blue-black at base but soon changing on dorsum to dark violaceous metallic and finally to cupreous metallic on the terminal segments: segment 7 with a small tuft of short black silky hairs beneath, at its basal end: segment 8 clothed throughout the length of its ventral surface with similar hairs but more densely so near its base where they extend on to the pleurites: segment 9 naked in this respect but 10 with a sparse clothing beneath. Anal appendages: superiors as long as segment 10, broad at base, tapered as seen from above to the apex, which is obtuse. A dorsal carina extending nearly to apex of appendages, whilst a shorter one beneath runs from near the inner side of base to the outer side of appendage just short of its apex: this latter ridge raised into a robust flattened spine at its middle and separated from the inner border of appendage by a long deep narrow sulcus. Above and to the inner side of appendage is a broad rounded projection at the middle third, followed by a second more shallowly

convex and smaller one, the two projections separated by a deep notch. Outwardly the appendage is nearly straight, curving in gently only towards its apex. Finally the base is deeply hollowed out below, the cavity extending into the sulcus mentioned above. Inferior appendages less than half the length of superiors, broad at base, then cylindrical and truncate at apex, which is densely clothed with long curling coarse hairs.



2

FIG. 2.—Anal appendages of *Mnesarte hincksi* sp. n., male, dorsal and left ventral aspects.

Habitat: ECUADOR and S.E. COLOMBIA: Umbria, a single male, 6.i.31. The *type* will be deposited in the British Museum (N.H.). This new species is unique on account of the clothing of hairs on the ventral surface of abdominal segments 7, 8 and to a lesser extent on 10, which recalls a similar ornamentation found in the widely separated Asiatic *Indophaeas*. From other species of the genus, it is also separated by the very differently shaped anal appendages. This species does not fit readily into either of the Selysian groups although the occipital tubercles are practically obsolete as in *M. pudica* (Selys), but the narrow uncoloured wings and the long slim legs exclude any close relationship with this species. When I sent particulars of this new species to Dr. Kennedy, he informed me that he had had examples of it for some years past from Ecuador but that other work had interfered with his publishing its description before now; he has kindly waived his rights in my favour, but it is hoped that he will before long publish the description of the female, which I do not possess.

The species is named after Mr. W. D. Hincks in acknowledgment of his work in entomology.

Mnesarte hauxwelli (Selys) (text-fig. 3).

Lais hauxwelli Selys, 1869, *Bull. Acad. Belg.* 27 (2) : 654.

Lais hauxwelli Selys, 1873, *Bull. Acad. Belg.* 35 (2) : 476.

Lais fulgida Selys, 1879, *Bull. Acad. Belg.* 47 (2) : 365.

Lais hauxwelli Selys, 1880, *C.R. Soc. ent. Belg.* 23 : xlix, 1.

Lais hauxwelli Kirby, 1890, *Cat. Odon.* : 103.

Lais fulgida Kirby, 1890, *Cat. Odon.* : 103.

Lais fulgida Calvert, 1909, *Ann. Carnegie Mus.* 6 : 80.

The female of this species has not been described so far and the description of the male leaves much to be desired and interpreted since it has appeared

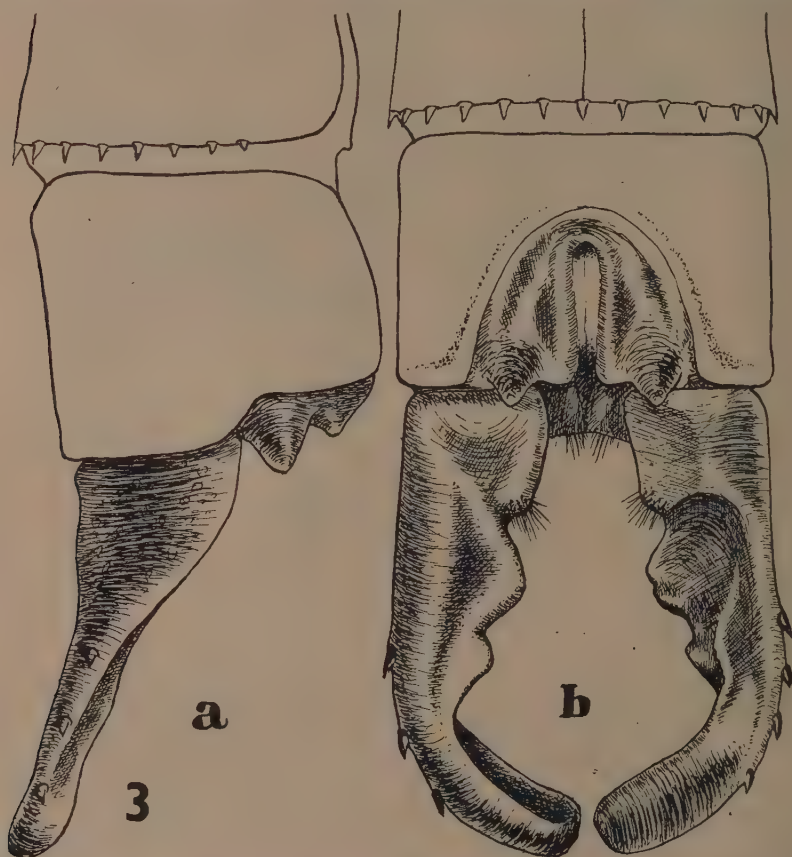


FIG. 3.—Anal appendages of *Mnesarte hauxwelli* (Selys), male. *a.* Lateral aspect. *b.* Ventral aspect (but the dorsum of left superior appendage shown). Note the aborted inferior appendages.

under the names of at least four species, viz., *hauxwelli*, *cupraea*, *devillei* and *fulgida*. Of these, the teneral male of *cupraea*, described as that of *hauxwelli*,

is most probably *cupraea* since its inferior anal appendages are developed; that of *fulgida* is most certainly the teneral stage of *hauxwelli*, whilst that of *devillei* refers of course to an entirely different species. The initial confusion arose through Selys failing to appreciate that the inferior anal appendages of *hauxwelli* were rudimentary: these, in the type, he thought to be either missing or in a "too poor condition" to be seen. The same appendages of *fulgida* were never mentioned in descriptions, so that one is led to infer that they too were either missing or in too rudimentary a condition to be observed. More confusion was added by describing a poorly defined apical marking to the hind-wings of *fulgida*, described from a teneral specimen, and then contradicting this later by stating that there was no such marking. The poor condition of this latter, Selys himself explained by the teneral state of the type: a correct conjecture on his part, for it is altogether absent in teneral specimens of *hauxwelli* and of other species which bear such markings, poorly defined in more adult ones and well defined only in the full adults. Clearly, then, if a marking was present in the teneral *fulgida*, it would be well defined in the adult. Calvert, who has examined a pair labelled as *fulgida*, apparently by Hagen, states that the male bears a well-marked apical brown spot in the hind-wing and that the inferior appendages are undeveloped like *hauxwelli*. He therefore groups *fulgida* with *hauxwelli* but does not suggest that the two are synonymous.

The present collection contains examples of all four of the species mentioned above so that it has been possible to make careful comparisons and good camera lucida studies of all anal appendages. The revised description of *Mnesarte hauxwelli* follows:—

Male. Abdomen 35 mm. Hind-wing 25 mm.

Head: labium black, labrum and epistome black with a metallic violaceous reflex, genae glossy black, bases of mandibles black or pale yellow in tenerals, rest of head, including the underside, black with a dull coppery metallic reflex. Occipital tubercles present but small. Prothorax and thorax dark steely metallic violaceous blue especially on the sides, the dorsum with rather brilliant crimson metallic reflex, this varying according to age; the first and second lateral sutures and a complete frame around the metepimeron finely pale yellow. A similar fine line on the humeral suture in tenerals but this entirely obscured in full adults. Beneath dull black but the posterior part of pectus traversed by a white fascia. The lower parts of sides and beneath thinly pruinose in old adults. Legs rather long, slim, black. Wings hyaline, the hind pair with a dark blackish-brown apical subtriangular spot, poorly defined in subadults and altogether absent in the newly emerged imago; reticulation black, close; 26–28 antenodals in all wings; discoidal cells traversed 4–5 times. Abdomen brilliant metallic crimson on the dorsum, changing gradually to dark violaceous on the end segments, dull black beneath. Anal appendages black: superiors half as long again as the 10th abdominal segment, broad at base, this portion ending inwardly in a rounded prominence which is coated with stiff black bristles, and is followed by a large rounded projection, the inner border of which is slightly notched at its apex, after which follows a second projection, much smaller and tooth-like in shape, a deep notch separating the two. The apical third of appendage curved evenly inward, grooved on its lower surface and ending in an obtusely rounded apex. Outer border bearing 3–4 robust spines. Inferior anal appendages rudimentary, broad flattened plates bearing on the outer sides a small conical nipple-like eminence.

Female. Abdomen 27–30 mm. Hind-wing 25–26 mm.

Ground colour entirely similar to that of the teneral male, but old adults may assume the dull metallic violaceous blue of the adult male, and the lower parts of the sides of prothorax and thorax may be thickly pruinose. The bases of mandibles and basal segments of

antennae pale yellow, even in full adults: the yellow lines on the sides of thorax, including a humeral line, nearly always present but obscured by pruinescence in very old adults. Wings evenly but palely enfumed throughout: reticulation more open than in the male, 23-25 antenodals in all wings. Dorsal surface of abdomen generally duller than in the male and the tenth segment ending in a robust apical spine dorsally; anal appendages black, shortly conical; vulvar scales long, robust, extending to end of abdomen.

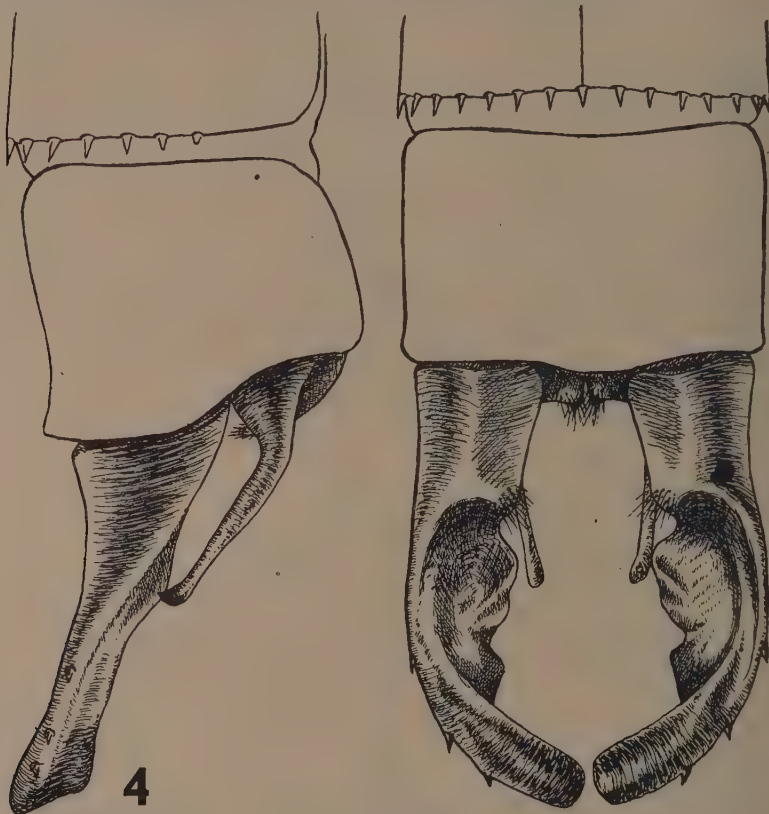


FIG. 4.—Anal appendages of *Mnesarte devillei* (Selys), male, lateral and dorsal aspects.

Habitat: PERU, ECUADOR and COLOMBIA. Material in the present collection from:—PERU: Mishuyacu, 2.i.31, 13.ii.31, 14.iv.31, 1.v.31, 21.v.31, 6.viii.31 and 20.viii.31, all males; 1 teneral male, COLOMBIA: Florida, 17.iv.31; 2 females, 1 adult and 1 teneral male all from PERU, Mishuyacu, Katzenbach, 15 km. v. Iquitos, 3.vi.30; 3 females, Umbria, S.E. COLOMBIA, 24.xii.30; 5 females, Mishuyacu, PERU, 28.iii.31, 21.v.31, 2.vi.31, 2.vi.30, 12.vii.30 and 14.viii.30.

Mnesarte devillei (Selys) (text-fig. 4).

Lais haurwelli Selys, 1879, *Bull Acad. Belg.* 47 (2): 365.

Lais devillei Selys, 1880, *C.R. Soc. ent. Belg.* 23: xlix.

Lais devillei McLachlan, 1881, *Trans. ent. Soc. Lond.* 1881: 26.

Lais devillei Kirby, 1890, *Cat. Odonata*: 103.

Male. Abdomen 39-42 mm. Hind-wing 29-30 mm.

Head: labrum black, labium steely blue-black, epistome glossy metallic coppery, rest of head above dull coppery or crimson metallic, beneath black; basal segments of antennae as well as genae invariably black. Prothorax and thorax crimson metallic, especially on the dorsum and especially brilliant in the subadult, becoming more dull in full adult: lateral sutures and the lower border of metepimeron pale yellow, finely so on the sutures. In teneral, vestiges of a similarly coloured fine line on the humeral suture. Beneath bronzed brown with two small round white spots on centre of pectus. Legs long, slim, violaceous black. Wings hyaline, with a pale brownish apical triangular spot on hind-wings; *the whole length of the subcostal space tinted with brown in all wings* (similar to what is found in *M. cupraea*): reticulation close, black, 26-27 antenodals: discoidal cells traversed 5-6 times, median space 6-9 times: pterostigma absent in all wings. Abdomen brilliant crimson metallic, changing to dark violaceous blue on the hinder segments. Anal appendages black: superiors about half as long again as segment 10, moderately broad and subcylindrical at base, this part ending on the inner side in a rounded angle coated with stiff short black bristles and separated by a rather deep notch from a broad subrotundate dilatation which is broadly and shallowly notched at its apex. This again is followed by a deep notch which separates it from a smaller, tooth-like projection. The apical fourth of appendage evenly curved inwards and ending in a rounded obtuse apex. Inferior appendage half as long as the superiors, slim and cylindrical, its base thick and conical, the stem arising from it at a marked angle, the apex slightly bulbous and ending in a short upturned spine-like point. The basal plate of this appendage is limited internally by a thickened curved ridge thickly coated with short hairs and visible in profile as a spine projecting above the level of the appendage's stem.

Female. Abdomen 30 mm. Hind-wing 25.5-27 mm.

A much more sombrely coloured insect than the male with the ground-colour of head, thorax and abdomen dark steely blue or violaceous black, the thorax bearing the same fine yellow lines on the sides but the humeral line more often present than absent and more often interrupted than complete. Labium, bases of mandibles and basal segments of antennae pale yellow, the former traversed from base to anterior border by a thick black band which splits the yellow into two lateral spots. Wings enfumed evenly throughout, somewhat greenish-grey in tint, reticulation close, black (*not red* as stated by Selys): 24-26 antenodals. Anal appendages black, shortly conical. Vulvar scales robust but not extending to the end of abdomen, but slightly overlapping segment 9, if at all. Segment 10 ending in a prominent apical dorsal spine.

Habitat: PERU and ECUADOR. The briefest description of this species was given by Selys under the synonym of *hauswelli* and but few details were added when it was raised to the status of a species in 1880. It is at once separated from *M. hauswelli* by its long cylindrical inferior anal appendages which are quite rudimentary in the latter. It is very closely related to *M. cupraea*, but in this species the inferior anal appendages are shorter and curved strongly up in their apical portion. A female from PERU: Balsapuerto, iii.33, which accompanies these specimens, probably belongs to the same species. It is distinguished by its inordinate size—abdomen 33 mm., hind-wing 29 mm.—but apart from this I am unable to find other differences except that it is much more heavily pruinosed on the sides and beneath than are any of the other specimens.

Mnesarte cupraea (Selys) (text-fig. 5).

Lais cupraea Selys, 1853, *Syn. Calop.*: 28 (♂).

Heterina cupraea Walker, 1853, *List Neur. Ins. Br. Mus.* 4: 614.

Lais cupraea Selys, 1854, *Mon. Calop.*: 92.

Lais cupraea Selys, 1869, *Bull. Acad. Belg.* 27 (2): 655 (♂♀).

Lais cupraea Selys, 1880, *C.R. Soc. ent. Belg.* 23 : 1.

Lais cupraea Kirby, 1890, *Cat. Odonata* : 103.

There is a single male of this species in the Leeds collection. It is a full adult with one of the superior anal appendages missing, but otherwise is in good

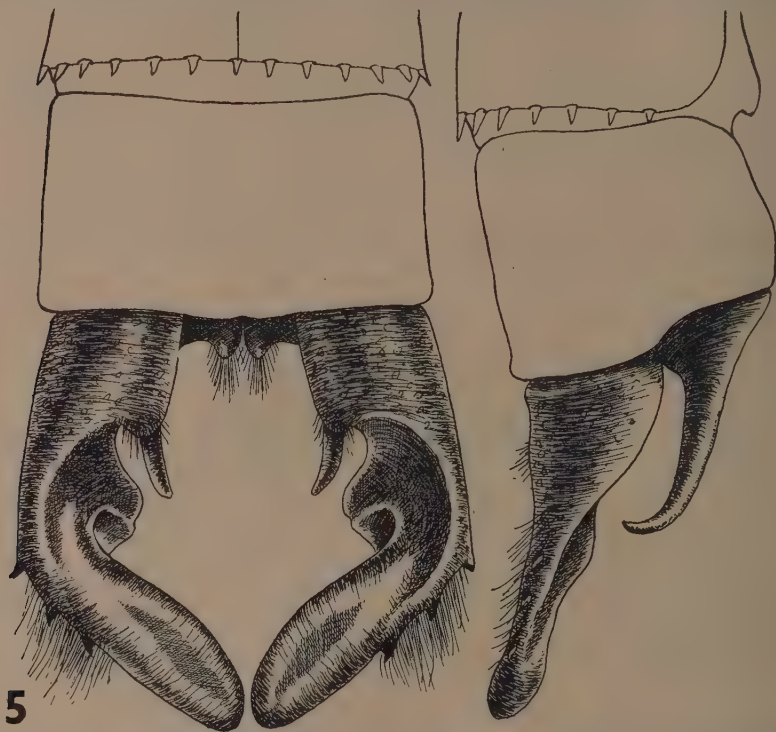


FIG. 5.—Anal appendages of *Mnesarte cupraea* (Selys), male, dorsal and lateral aspects. (The superior appendages are here shown strongly rotated outwards in order to demonstrate their outlines : normally the apices look inwards and downwards.)

condition. It agrees closely with the Selysian descriptions both as to size and colouring. The teneral male was thought by Selys to be *hauxwelli* but the rudimentary inferior anal appendages of the latter entirely rule this out. The adult male was also thought to be the very adult state of *aenea*, but this latter has no brown stripe in the subcostal space of the wings. It is clearly very closely related to *M. devillei* but the inferior anal appendages are considerably shorter than in this latter and their ends are sharply upcurved.

Habitat : BRAZIL ; PERU : Yumbatos, ix.32, 1 male.

Genus *Hetaerina* Selys.

Three species belonging to genus *Hetaerina* are represented in the Leeds collection, viz., *H. occisa* Selys, *sanguinea* Selys and a new species for which I propose the name *papavarina*. *H. sanguinea* is represented by two males from PERU : Mishuyacu, and COLOMBIA : Umbria, neither differing from type.

In a small series of this species sent to me by E. B. Williamson there is a male with a small but definite red spot to the apex of fore-wings, as well as one in the hind-wings: either, then, an incorrect determination of this specimen has been made or *sanguinea* and *laesa* Selys are synonymous. I am inclined to the latter view, as I can find no other differences separating them. *H. occisa* is represented by nine males, all from Peru, one from Yumbatos, September 1932, and the rest from San Antonio, November 1932 to February 1933: all are true to type, and save for a single teneral male are all fully adult. I employ the name *occisa* here in preference to that of *macropus* Selys, although this latter is the more generally used, because when Selys revised the descriptions and established their synonymy in 1878 (*Bull. Acad. Belg.* 35 (2): 17) he expressly chose the name *occisa* for the species. The name *macropus* has been used because it stands first in order in the same publication before the name *occisa*. Selys stated, "These two nominal species are but one for which it is convenient to reserve the name *occisa*," therefore, as the first reviser and under Article 21 of the International Rules the name *occisa* is the correct one to be employed.

***Hetaerina papavarina* sp. n. (text-figs. 6, a and b, 7, a).**

Male. Abdomen 40 mm. Hind-wing 30 mm.

Head: labium cinereous becoming brownish anteriorly and medially; labrum, bases of mandibles and lower parts of genae yellow, the former traversed by a thick black band from base to anterior border: epistome dark violaceous metallic, rest of dorsum of head dull cupreous metallic, beneath dull black: basal segments of antennae ochreous. Occipital tubercles prominent. Prothorax yellowish laterally, dull cupreous metallic on dorsum, with a rounded prominence on each posterior corner of middle lobe conspicuously metallic green. Thorax: middorsal carina narrowly black, dorsum dark crimson or coppery metallic changing to gold and green metallic outwardly above, this metallic band slightly overlapping the humeral suture at its extreme upper part and from that point gradually contracting in breadth anteriorly, thus leaving a broad bright ochreous band on its outer side. Laterally rich ochreous traversed by three metallic bands, the first broad and incomplete above and below, bordered narrowly with black posteriorly, green metallic below but changing, like the colours of the spectrum, to gold and finally crimson metallic above: the second stripe situated in the middle of the mesepimeron, broad above where it is dark green metallic, narrowing and becoming black below and ending short of the coxae of legs: final stripe linear, centred on metepimeron, strongly angulated posteriorly and dull green metallic in colour. Finally a small black spot on upper part of postero-lateral suture. Beneath thorax pale yellow with two small ill-defined black spots at centre of pectus and the posterior border prominently margined with black. Legs very long and slender, black. Wings hyaline, apex of hind-wing only with a strongly marked triangular poppy-coloured apical spot: fore-wing with a similarly coloured basal marking which extends distally to about 2 cells beyond the outer end of discoidal cell, with a straight outer border but a little notched above and below and extending from R + M to the posterior border of wing: subcostal space tinted brown for its basal half. Hind-wing with this same space brown for about its basal three-fourths and the whole of the cubital space save for one or two cells distally of the same colour: the space between these two brown stripes poppy red to as far as level of arculus and from thence obliquely towards the Radius to nearly as far as the end of the subcostal brown stripe. A reddish-brown area also invades the costal space irregularly, adjoining the subcosta but ending short of the distal end of the subcostal stripe. Reticulation close, especially in the basal space and the anal field of fore-wing which is densely reticulated: 30-32 antenodals, discoidal cells traversed 9-12 times, pterostigma absent. Beneath wings, the antenodals in the subcostal space of both wings and the cross-veins in the

cubital space of hind-wings are pure white. Abdomen dull reddish-brown deepening to broad black apical rings on segments 2 to 6 and black throughout thereafter: segment 1 metallic green on dorsum. Anal appendages black, superiors nearly twice the length of segment 10, forcipated, broad and subcylindrical at base, tapering rather rapidly for the basal third, then but slightly so to as far as the apex, which is obtuse and rounded: on the inner side after the broad basal portion, a broad rounded dilatation which is separated from a smaller, tooth-like one which follows by a moderately deep notch: from this latter runs a

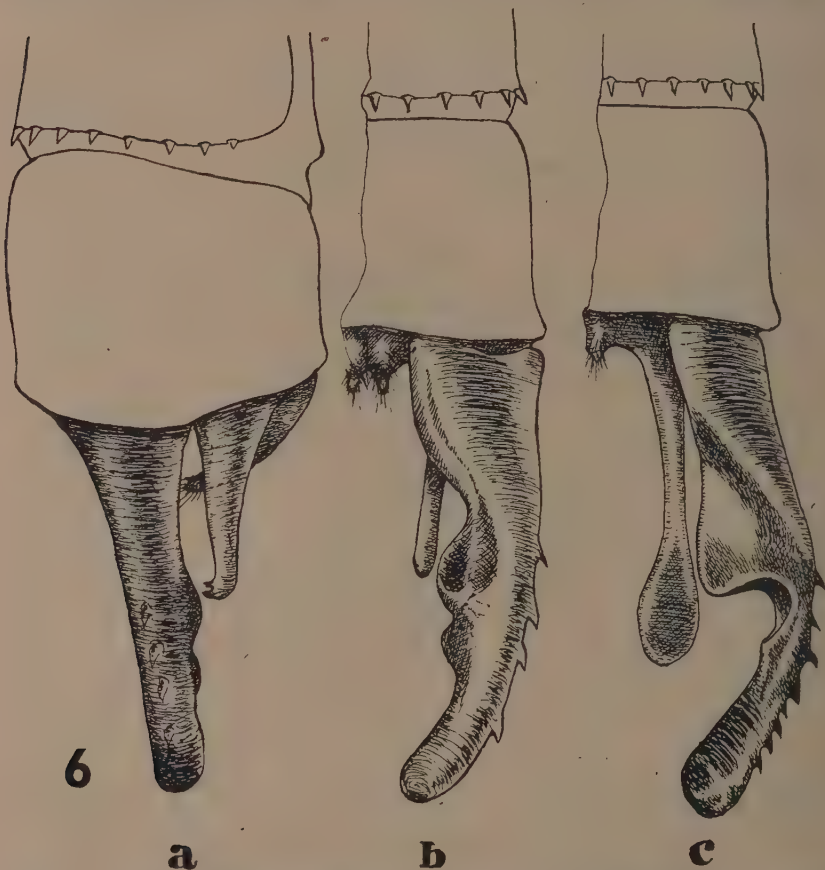


FIG. 6.—Anal appendages of *Hetaerina papavarina* sp. n. a. Lateral aspect. b. Dorsal aspect. c. *Hetaerina occisa* Selys, dorsal aspect.

ridge basad and outwards, its surface coarsely wrinkled and its border coarsely crenulate. The appendage slightly and evenly curved inwards towards its apex and with four or five small spines along its outer border. Inferior appendage about half the length of superiors, broad at base and tapered to apex which bears two small upturned spines. The base of this appendage extended inward, where it is raised into a thick curved ridge, which, seen in profile, appears as an upturned spine just beyond the base of the stem of the appendage.

Female. Abdomen 31-35 mm. Hind-wing 27-30 mm.

A shorter, more robust insect than the male with the wings rather broader and tinted throughout with amber, this colour deepening basad somewhat and along subcosta: reticulation rather more open, 26-29 antenodals, 6-7 median cross-veins and 5-9 cross-veins in the discoidal cells. Labium paler, labrum entirely yellow save for a minute black spot at its middle or a narrow basal black line: basal segments of antennae bright yellow: epistome golden metallic, dorsum of head and all dark markings of prothorax and thorax metallic emerald green, or the dorsum of thorax metallic peacock blue. Markings similar in shape and position to those of male; coxae, trochanters and flexor surfaces of femora pale brown. Abdomen reddish-brown. Anal appendages black, shortly conical. Vulvar scales extending midway along segment 10.

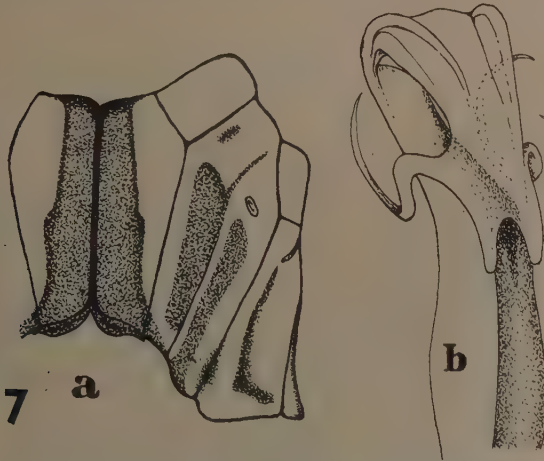


FIG. 7:—a. Thoracic markings of *Hetaerina papavarina* sp. n., male.
b. Penis of *Polythore procera* (Selys) (= *picta* Rambur).

Habitat: PERU: Mishuyacu. Nine males and 10 females taken from 18.vi.30 to 8.xii.30. Two pairs from Mishuyacu, Katzenbach, 15 km. v. Iquitos. One of the males has been determined by Mr. Kimmins as *H. laesa* Selys var., but it must be pointed out that this species belongs to the Selysian Group 1, c, in which all four wings possess an apical red spot. There is no trace of such a marking in the fore-wings of any of the present specimens although all are adult. Unfortunately I possess only two males of *H. laesa* (determined by Williamson) and both are so teneral that neither has, nor can be expected to have, any red apical markings in any of the wings, although one has traces of red markings at the base of the wings. These specimens are part of a series from Minas Gerães and although Williamson noted that, contrary to the description of *laesa*, none of them showed any trace of an apical marking in the fore-wing, he persisted in determining them as that species. In the present specimens, the basal markings are much more extensive than in *laesa* and the reticulation of the wings is much closer (4-6 cross-veins in the discoidal cells of *laesa* as compared with about 9-12 in *papavarina*). The anal appendages of *laesa* type are unknown, so that no comparison can be made, but the other points of difference are so broad that I have no doubt the present specimens belong to a new species.

Superfamily Coenagrionidea.

Family COENAGRIIDAE.

Genus *Acanthagrion* Selys.

This genus has been divided into three convenient groups based partly on the length of petiolation of the wings and partly on the shape of the 10th abdominal segment. In the first group petiolation of the fore-wing begins at the level of the anal tracheal crossing (Ac) where Ab meets Ac; the 10th segment has the apical border raised into a truncate tubercle at the middorsum—group-type *Agrion gracile* Rambur. In the second group, the petiolation is as for the first group but the 10th segment presents a pair of more or less

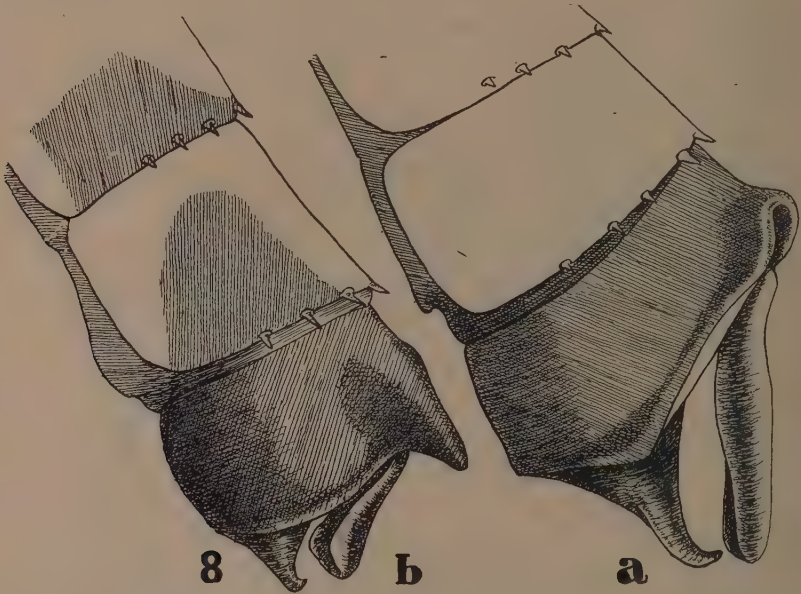


FIG. 8.—Terminal segments of abdomen and anal appendages of:—a. *Acanthagrion gracile floridense* subsp. n. b. *Acanthagrion apicale luna* Ris.

widely divaricate conical processes on the dorsum of its apical border—group-type *Acanthagrion apicale* Selys. The third group has a shorter petiolation, Ab meeting the posterior border of the wing proximal to Ac in the fore-wing: the 10th segment is variable but usually emarginate or with two small points at the apical border—group-type *Acanthagrion interruptum* Selys. There are four species of *Acanthagrion* in the Leeds Museum collection, one of which belongs to group *gracile* and three to group *apicale*. The first of these two groups contains species closely similar in colour and markings, and often also in the shape of the 10th segment. Kennedy has shown that these species may be easily separated by the shape of the penis, and it is this organ which I have largely employed for identifying the present specimens, two of which are new subspecies.

Group *gracile*.***Acanthagrion gracile floridense* subsp. n. (figs. 8, a, 10, 2 & 3).**

Male. Abdomen 25 mm. Hind-wing 16 mm. (Female unknown.)

Ground colour of thorax azure blue, markings similar to typical *A. gracile gracile* (Rambur), with which the present specimen was at first confused: it differs, however, by the formation of its penis, etc. The wings are hyaline, 11 postnodals to fore-wings, 9 in the hind-wings: 3 postdiscal cells to level of nodus: Riii arising at the level of the 5th postnodal, IRiii at the level of the 8th: pterostigma dark brown, about one-third longer than broad, very oblique, covering less than one cell. Abdomen: segment 2 has the dorsal band complete

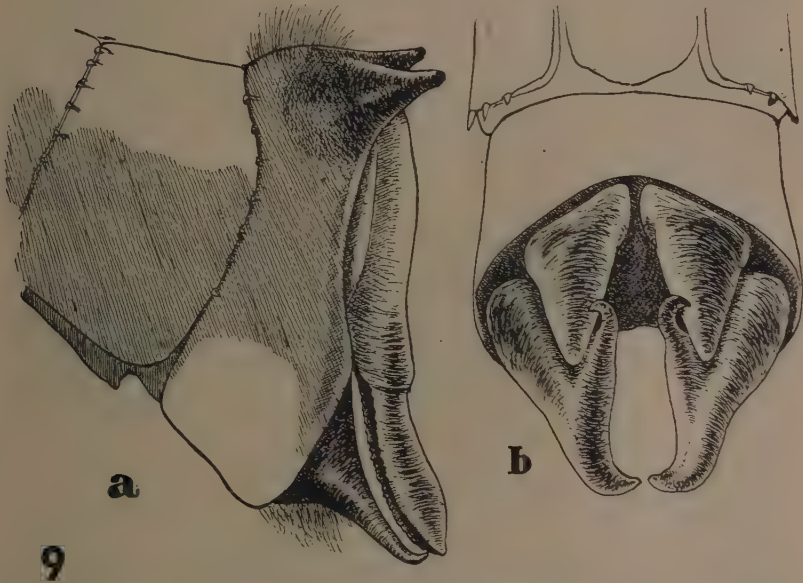


FIG. 9.—Terminal segments of abdomen and anal appendages of:—a. *Acanthagrion apicale descendens* subsp. n., seen from the left side. b. *Neoneura denticulata* Williamson, ventral view.

but tapering slightly towards the base, segment 7 has a small sagittate blue spot covering its apical fourth dorsally, segments 8 and 9 and a small spot on the dorsum of 10 all azure blue. Segment 10 narrowly and deeply notched on its apical border, which is elevated rather more than in typical *gracile*. Anal appendages: superiors sloping steeply downwards, elongate and constricted rather abruptly in the apical third as seen in semi-profile, obtusely pointed. Inferiors projecting posteriorly nearly as far as level of apices of superiors, their apex pointed and curled up slightly, otherwise very similar in shape to group-type. Penis with a long tongue-like process extending obliquely downwards and forwards from the 3rd segment, simple in outline but otherwise not unlike that of *gracile ascendens*.

Habitat: S.E. COLOMBIA: Florida, 7.iii.31. A single male, the type, which will be deposited in the British Museum (N.H.). The late E. B. Williamson wrote—"In view of Mr. Kennedy's work on *Acanthagrion* penes and because of the specific distinctness of forms otherwise scarcely separable, the true status

of *gracile* and the many varieties discussed by de Selys is a matter for future determination." He had determined specimens from Trinidad as *gracile* but when submitted to Kennedy, the latter showed that the penis was quite different from that species and the Trinidad species was subsequently named *kennedyi*. Similarly I had determined this specimen from Florida as typical *gracile* until I examined the penis and found, to my great surprise, that it was markedly different. I have been assisted greatly in this determination by having cotypes of *kennedyi* Williamson, *ascendens* Calvert from Brazil, Trinidad and British Guiana, and *adustum* Williamson from the last country, determined by Williamson and Calvert.

Group *apicale*.

Acanthagrion apicale apicale Selys.

There are two males belonging to this species in the collection, both fully adult and with vivid orange markings. The only difference which I note from type is that the pterostigma is an intense blood-red, especially by transmitted light.

Habitat : PERU : Mishuyacu, I.viii.30.

Acanthagrion apicale luna Ris (figs. 8, b, 10, 1).

Acanthagrion luna Ris, 1918, *Archiv für Natur.* 82 (9) : 122, f. 64.

There are a large number of both sexes of this subspecies (which agree entirely with Ris's description and figure) in the Leeds collection. All are from COLOMBIA : Umbria, from 9-10.xi.30. The type was from Villavicencio in the same country. Ris stated that the colour and anal appendages are typical of Group *gracile* but that the shape of the 10th segment is very different. I agree with this opinion, but consider that the shape of this segment places *luna* very definitely in Group *apicale*.

Acanthagrion apicale descendens subsp. n. (figs. 9, a, and 10, 4).

Male. Abdomen 29 mm. Hind-wing 19-20 mm. (Female unknown.)

Head : labium palest yellow : labrum, genae and face as far as and including the basal joints of antennae blue, vertex and occiput black with a large round postocular spot of blue : below and behind eyes pale. Prothorax black on dorsum, with a broad pale blue spot on each side. Posterior lobe of prothorax broadly and flatly arched and fringed with hairs. Thorax black on dorsum, with broad complete blue antehumeral stripes, broadening gradually below where they are broader than the black middorsal stripe which they enclose : the sides pale blue with a narrow blackish-brown stripe on the upper three-fourths of the postero-lateral suture. Beneath pale caraneous. Legs pale, femora with a fine black line on the outer sides, thickening at the distal end, tibiae black on flexor surface, spines and tarsi black. Wings hyaline : 12 postnodals to fore-wings, 10 in the hind-wings, Ac meeting Ab on the margin of wing, the former midway between the levels of the two antenodals or slightly nearer the proximal one. Pterostigma very oblique, diamond-shaped, covering 1 cell, pale brown. Abdomen long and slim, greatly broadened at segment 10, the dorsum of which presents two large conical eminences with their apices divaricate. The whole dorsum from segment 1 to 7 black, this black expanding apically on all segments from 2 to 5 to almost completely ring them : dorsum of segments 8 and 9 azure blue, 10 black with a large ventro-lateral spot of blue. Anal appendages : superiors narrow, elongate, sloping strongly downwards from above backwards, obtusely pointed ; inferiors broad at base, then abruptly thinning to form long curved spines with an acuminate apex

directed upwards and inwards. The 10th segment with two divaricate conical dorsal processes on the apical border: penis closely similar to that of *A. ascendens* Calvert but with an extra lateral flagellum on each side situated between the apex and the normal lateral flagellum.

Habitat: PERU: Mishuyacu, a single male, the *type*, which will be deposited in the British Museum. This new subspecies differs from *A. apicale apicale* Selys

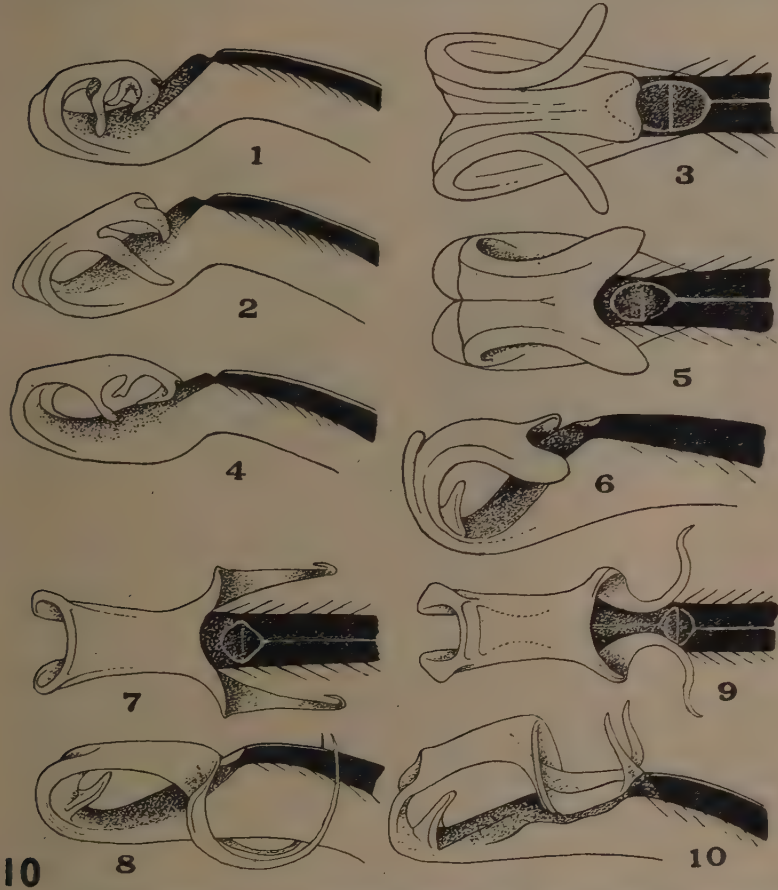


FIG. 10.—Penile organs of:—1. *Acanthagrion apicale luna* Ris. 2 and 3. *Acanthagrion gracile floridense* subsp. n. 4. *Acanthagrion apicale descendens* subsp. n. 5 and 6. *Oxyagrion terminale* Selys. 7 and 8. *Neoneura denticulata* Williamson (Original). 9 and 10. The same (after Kennedy).

by the greater depth of segment 10, by the ground-colour blue instead of ochreous and by the shape of the penis which has two lateral flagellae converging towards one another on each side. Apart from this character, the penis is remarkably like that of *ascendens* Calvert but the adult stage is orange or ochreous in that species in addition to other differences. Williamson states

that the teneral stages of this latter species and others is blue, changing in the adult state to orange : if this is correct, then it is in direct contradiction to the general rule prevalent in the COENAGRIIDAE.

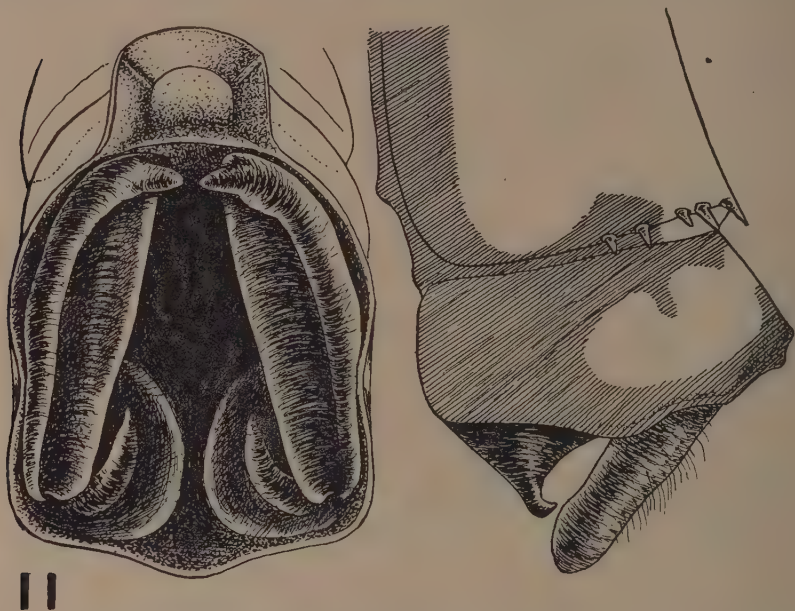


FIG. 11.—Anal appendages of *Oxyagrion terminale* Selys, seen from behind and from the left side.

Genus *Oxyagrion* Selys.

Oxyagrion terminale Selys (figs. 10, 5 & 6, 11).

- Oxyagrion terminale* Selys, 1876, *Bull. Acad. Belg.* **41** (2) : 295 (sep. 51).
Oxyagrion terminale Kirby, 1890, *Cat. Odon.* : 144.
Oxyagrion terminale Ris, 1904, *Hamb. Magaelh. Sammelr. Odon.* : 9, f. 2.
Oxyagrion terminale Calvert, 1909, *Ann. Carnegie Mus.* **6** : 179.
Oxyagrion impunctatum Calvert, 1909, *ibid.* **6** : 188, pl. 3, f. 56, 57.
Oxyagrion terminale Ris, 1913, *Mem. Soc. ent. Belg.* **22** : 69, 94.
Oxyagrion terminale Ris, 1918, *Archiv für Naturges.* **82**(A) (9) : 127.
Oxyagrion terminale Campion, 1922, *Ann. Mag. nat. Hist.* **10** (9) : 292.

It is convenient to mention here a male belonging to this species, sent to me from ARGENTINE : Concordia, xii.1931, by Capt. K. J. Hayward. The colours of this specimen are preserved as in the living insect, so that it is possible to add to former descriptions. The labium, labrum and genae are pale creamy yellow, the labrum marked with a tiny midbasal tongue of black : the anterior part of the head, described as blackish by Selys, is dark reddish-brown and this area is separated from a pale yellowish postocular area by a narrow black stripe which runs forwards and outwards to each eye from the occipital region. The sutures of the prothorax are narrowly black and the middorsum of the middle lobe has a black marking shaped like a fleur-de-lys. The dorsum of thorax is dark reddish-brown, becoming lighter red or brick-red outwardly and fading to

pale carneous on the sides and below. On the dorsum, the whole area is peppered with minute black dots, from each of which springs a black hair. (A similar character is given by Selys for *O. basale* and Calvert gives the absence of this character in his *impunctatum* as the chief means for separating it from *basale*. It is not mentioned for *terminale* by Selys, so is presumably absent in the type: thus the character is a variable one and may be present or absent and the chief character between *basale* and *impunctatum* is shown to be non-dependable.) The pectus is marked centrally by a sharply-defined small black spot shaped like the ace-of-clubs. The wings are hyaline, with 10 post-nodals in the fore and 8 in the hind pair: the pterostigma is highly characteristic, as stated by Selys: its pale yellowish costal border is in strong contrast to the dark blood-red of the rest of the organ. In the present specimen, there is a narrow line of pale blue intervening between the costal yellow and the dark red centre of the pterostigma. Abdomen vivid blood-red with the inter-segmental nodes narrowly black: the whole of the dorsum of segments 7 and 8, save for the extreme base of the former, black; segments 4 to 6 have also a trace of this black marking at the apical end, well marked in 6 but a mere clouding on 4 and 5. The dorsum of segments 9 and 10 pale azure blue, bordered laterally with black followed by dark blood-red. On segment 10, the blue is enclosed in black by narrow basal and apical black borders, the black invading the blue basally as two fine points. Anal appendages entirely similar to those given by Calvert for his *impunctatum*, which species I believe to be the same as *terminale*. Penis almost entirely similar to that figured by Kennedy for *Acanthagrion adustum* Will. (1916, *Ent. News* 27: pl. 18, figs. 20, 21). Very little separates the two genera *Oxyagrion* and *Acanthagrion*: venation of wings, genitalia and anal appendages are similar: colour differences are all that can be pointed out: thus the student is advised to rely entirely on the genitalia and anal appendages for the determination of species, as in the genus *Acanthagrion*.

Oxyagrion cardinalis sp. n.

Female. Abdomen 33 mm. Hind-wing 20 mm.

Head: labium yellowish, cleft for about half its length, labrum pale ferruginous, clypeus, epistome and bases of mandibles pale bluish, rest of head rust red, including the two basal segments of antennae, but excluding the apex of the second segment, which, with the remaining segments, is black. A fine black line dividing the occiput from vertex: beneath head pale olivaceous grey. Prothorax ferruginous, the sides mottled with pale blue, the posterior lobe produced at its apex, forming a truncated lobe, which projects at an obtuse angle upwards and backwards. Seen from above, this lobe is crenate, the middle lobe slightly notched. Thorax with its anterior border raised to form a ridge projecting forwards towards the posterior lobe of prothorax; golden reddish-brown or rich ferruginous on dorsum, somewhat darker middorsally and marked by complete antehumeral and humeral violaceous blue stripes, the former narrow but expanding slightly upwards, the latter slightly broader and continued above on to the axillary of fore-wing. Whole of sides posterior to the anterior lateral suture palest blue, as also the pectus, which is nearly white. A linear black spot on lower posterior angle of metepimeron, and a conspicuous black spot just below the root of each wing, the posterior of these on the upper part of the posterolateral suture. Legs pale ferruginous, spines black, robust, as long as the intervening spaces, 5-6 in number. Claw-hooks well developed. Abdomen dark ferruginous to dark brown; segments 3-6 with apical black rings, one-sixth to one-seventh the length of segments; sides of segments 1 and 2 blue, of the rest yellow; the final three segments paler, reddish but possibly blue in the living state. Ovipositor extending a little beyond end of

abdomen : 8th segment with a very prominent ventral spine; anal appendages brownish, shortly conical, as long as segment 10. Wings hyaline : 13 postnodals in fore-wings, 11 in the hind-wings; discoidal cell acute outwardly, its base about equal in length to costal side in fore-wings, but the latter side more than twice the length of the base in the hind-wings; Ac about midway between the two antenodals or slightly nearer the distal in the hind-wings; IRiii arising at subnodus, Riv + v proximal to the subnodus, the two not approximated after their origins, Rii and IRiii, at the 6th and 9th postnodals respectively. Pterostigma similarly shaped in all wings but slightly smaller in size in the hind-wings, nearly quadrate, sides parallel but very oblique, golden yellow in colour with dark greyish centre and thick black framing nervures. Petiolation very slightly distal to the level of Ac; arculus at or a shade distal to the 2nd antenodal.

Habitat : PERU : Mishuayacu. A single female, 14.iv.30, the *type*, which will be deposited in the British Museum (N.H.). Male unknown. This species differs from all others of the genus by the conspicuous blue thoracic stripes strongly contrasted against a rich reddish background. Venationally and by the presence of a ventral spine to segment 8, the species falls best into genus *Oxyagrion*. In colouring, it is reminiscent of *Aeloagrion flammeum* (Selys).

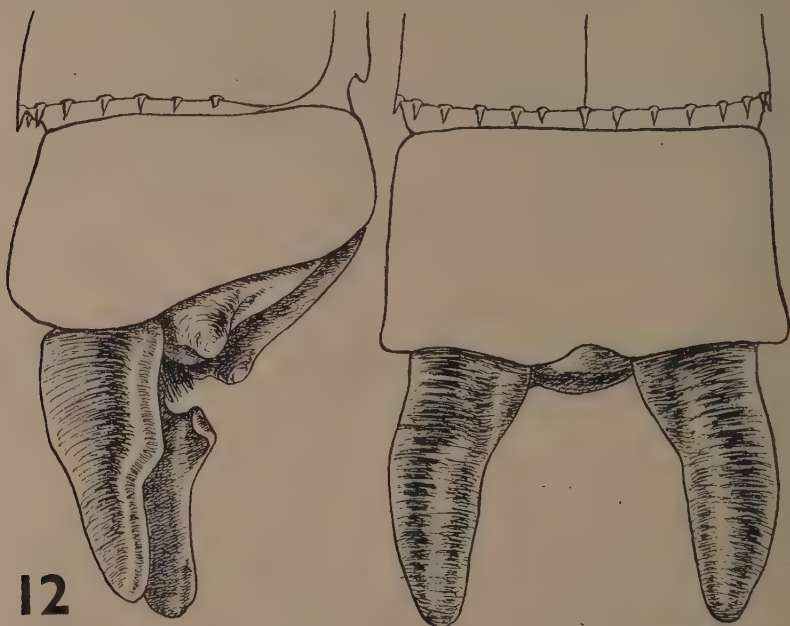


FIG. 12.—Anal appendages of *Telebasis versicolor* sp. n. Right lateral and dorsal aspects.

***Telebasis versicolor* sp. n. (fig. 12).**

Male. Abdomen 29 mm. Hind-wing 18 mm.

Head : labium brown; labrum glossy black, genae, bases of mandibles turquoise blue, rest of head dull jet black, but a short, fine reddish streak running from the outer ocellus to the base of antenna. Beneath head and eyes dull black, but a narrow band of blue bordering the eyes extending from the blue of genae. Frons prominently ridged as in genus *Ceria-*

grion. Prothorax dark ferruginous on the dorsum, blue laterally. Posterior lobe prominent, truncately lengthened. Anterior lobe forming a raised ruff-like collar. Thorax with a broad bronzed black middorsal stripe extending outwards half-way to humeral suture and bordered outwardly by a broad reddish-brown stripe or fascia which extends to as far as the first lateral suture: rest of sides pale olivaceous but bluish from an overlay of thin pruinescence. Legs pale yellow, the anterior pair of femora pale ferruginous and dark on the extensor surface. Spines black, 5 on the femora, 5-6 on the tibiae, all as long as the spaces separating them. Tarsal claws robust, *equal in length*. Wings hyaline: 12 post-nodals in fore-wings, 11 in the hind-wings: discoidal cell acute distally, the base nearly half as long again as the costal side in fore-wing but the reverse of this in the hind-wing; Ac about midway between the two antenodals or slightly nearer the distal; IRiii arising from the level of the subnodus, Riv + v well proximal to that level, the two not approximated after origins; Riii and IRii from the 6th and 9th postnodals. Pterostigma narrow, nearly half as long again as broad, very oblique, the sides parallel, covering 1 cell, dark reddish-brown in colour. Arculus a shade distal to the second antenodal. Petiolation extending to the level of Ac or a shade distal to that vein. Abdomen vivid reddish orange with the articulations finely black, segment 1 with a poorly defined middorsal blackish spot, blue laterally, segment 4 and the whole length of segments 5 to 7 black on dorsum, the remaining segments unmarked. Anal appendages reddish-brown: superiors slightly longer than segment 10, broad at base, tapering slightly to as far as apex which is obtusely rounded. Seen in profile the outer surface is convex, rather abruptly constricted just beyond its middle, the basal part broadened into a thin scale-like expansion which is produced ventrally at the base as a short broad truncated prominence with its edge curling inwards. Inferior appendage rudimentary, very short, with a rounded angulation or tubercle near its apex, which is directed upwards between the superiors.

Habitat: S.E. COLOMBIA: Umbria. A single male, the *type*, which will be deposited in the British Museum. The venation of this species places it near *T. livida* Kennedy, but it is easily distinguished from this latter and all others of the genus by the unique shape of its superior anal appendages. The general venation and the prominent frontal ridge appear to indicate a very close relationship between the genera *Telebasis* and *Ceriagrion*.

Neoneura denticulata Williamson (figs. 9, b, 10, 7-10 and 13).

Neoneura denticulata Williamson, 1917, *Trans. Amer. ent. Soc.* 43: 227, figs. 10, 44, 45 and 83.

Neoneura denticulata Kennedy, 1917, *Ent. News* 28: 292, figs. 51, 52.

Neoneura pardalina Sjöstedt, 1918, *Arkiv Zool.* 11 (15): 24, Pl. 2, f. 16.

There are four specimens of *Neoneura denticulata* Williamson in the Leeds collection, of which one is a complete and nearly fully adult male, whilst the rest are females, only one being complete and all more or less teneral. The type, the only specimen hitherto known, is a teneral male in poor condition and—to employ the author's own words—"only the distinct abdominal appendages justify its description and designation as a type." However, Dr. Kennedy appears to have examined and described the penis of this specimen subsequent to its description by Williamson, and this organ was found to have very distinctive specific characters, thus fully justifying Williamson's action. It is mainly on the evidence of the characters of the penis that I have determined the present material as belonging to *denticulata*, although, as will be seen by reference to the text-figures 10, 7-10, there are some slight differences from the type: however, I feel satisfied that the teneral condition of the type has led to some distortion and compression, sufficient to cause these differences and that the true shape of the penis is as shown in my figures 7 and 8, drawn from an

adult male. The variation of the dorsal thoracic pattern of markings appears to be infinite but all are of the "worm-eaten" pattern: that is, they resemble the network of subcortical channels and tunnellings made by some coleopterous larva. This extreme variation is fully exemplified in the present material, where it ranges, in the case of the three females, from Williamson's figure 13, through 10 and 9 but fails to agree entirely with any: thus colour and markings

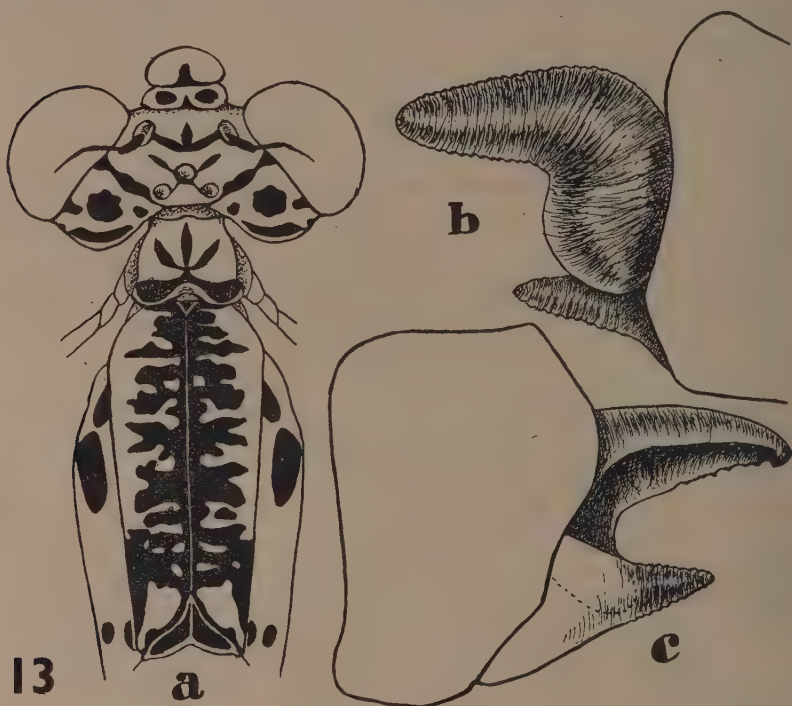


FIG. 13.—*Neoneura denticulata* Williamson:—a. Head and thorax to show the intricate markings. b. Anal appendages of male seen from the right side. c. The same but with the left superior appendages removed to show the inner side of the right.

appear to be useless for identification purposes and the student is advised to rely entirely upon the shape of the male anal appendages and the penile organ. The adult male and the female sex are described here for the first time.

Male. Abdomen 22 mm. Hind-wing 17.5 mm.

General body colouring dull ochreous changing to bright red on the abdomen. Dark markings of head similar to those described for the type except that there is no oblique line running forwards and inwards from the root of each antenna. A short, well-defined basal medial tongue of black on labrum: a similar one at base of clypeus, as well as two large oval submedial spots in front and below this. The large rounded postocular spots have a crenulate circumference and are distinctly steely by reflected light. Prothorax with a trident-shaped middorsal marking on middle lobe and a transverse bar of black on the posterior lobe, which is shaped as figured by Williamson for the male. Thorax with the dorsum transversely striated with black or blackish-brown in a very variable and very

irregular pattern, the striations tending to become confluent (as they most probably ultimately do in old adults?). The antealar sinus black: above, the striations become confluent and extend to and even across the humeral suture at its extreme upper limit. A small oval black spot on upper part of mesepimeron but slightly separated from the upper humeral black, whilst below, a somewhat larger oval spot adjoins the lower part of the same suture and is more or less separated from a very large wedge-shaped black spot on middle area of mesepimeron (the former spot is present in most species of *Neoneura* and may be considered as generic in character, whilst the wedge-shaped spot is almost as frequently present and often broadly confluent with the former spot). Laterally a small black spot marks the lower limit of the first lateral suture, whilst the second lateral suture is heavily outlined in black for its entire length, the marking passing ventrally across the pectus to become confluent with the same marking from the opposite side. Lastly a small black spot on the posterior part of metepimeron and a pair of small black spots on pectus more or less obscured by pruinescence. (The markings, as described here, agree closely with those of the female of *N. mariana* Will., as figured by the author (*loc. cit.*, fig. 9).) Legs not differing from type. Wings with 9 and 8 postnodals for the fore- and hind-wings, respectively. (In one wing of the male, the first postnodal cross-vein ends on the posterior border of the wing as a bifurcation enclosing a four-sided cell as described by Selys for *N. waltheri*: it is evident that this condition is a mere aberration.) Abdomen red or reddish ochreous; segment 1 with a black quadrate spot on dorsum not quite extending to apex of segment; intersegmental nodes narrowly black, a black spot on each side of segment 9 and a pair of obscure dark spots on dorsum of segment 10. Ventrally black, this extending as far as the 7th, 6th or even 5th and slightly so on to the sides of segments. Penis agreeing with Kennedy's figures, if allowance be made for some distortion or displacement in the type due to its teneral and poor condition. (Fig. 10, 7—10.)

Female. Abdomen 22 mm. Hind-wing 17.5 mm.

Markings and colouring very similar to those of the male but with the same extreme variations on dorsum of thorax: in the most teneral specimen the transverse striations are alternately dark and pale as in Williamson's figure 13 (*loc. cit.*), and there is a chain of dark spots on the middorsal carina, which latter finely bisects each. Abdomen is more ochreous than reddish, and darkens on the final segments: ovipositor robust but short; anal appendages shortly conical, yellowish. Posterior lobe of prothorax bilobate, each individual lobe broadly rounded and the intervening notch narrow and deep.

Habitat: PERU: Iquitos and Mishuyacu near Iquitos, 2-24.vii.30. The type male is from Iquitos, the present specimens from Mishuyacu. Sjöstedt's *pardalina* is from the Amazons, between Manáos and Teffé; it has the end of the abdomen missing and the penis has not been described by the author; the close similarity of the dark markings, especially the intricate pattern on the head, are similar to the present specimens so that I have no doubts about the synonymy. *N. rubriventris* Selys, *mariana* Williamson, and *denticulata* Williamson, are three species which appear to have at equivalent ages the same colouring and thoracic markings and are intimately related to one another, differing only in the formation of their genitalia.

EXPLANATION OF PLATE 1.

- FIG. 1. Wings of *Euphaea picta* Rambur (*Polythore*), type male, in the Hope Museum, Oxford. (The dark ray proximal to the black apex of wings is actually an opaque white band.)
- FIGS. 2, 3. Wings of *Polythore albovittata* (Selys), determined and photographed by Dr. E. Schmidt.



Wings of *Euphaea picta* and *Polythore albobittata*.

ENTOMOLOGICAL SOCIETY
LIBRARY

1 MAY 1946
AL
ENTE
Eu. 344.

Vol. 96. Part 3. Pp. 47-60, 25 figs.

30th April, 1946.

THE
TRANSACTIONS
OF THE
ROYAL
ENTOMOLOGICAL SOCIETY
OF
LONDON

World List abbreviation: Trans. R. ent. Soc. Lond.

CONTENTS

	PAGE
X EVANS, J. W., M.A., D.Sc. A natural classifica- tion of leaf-hoppers (Jassoidea, Homo- ptera)	47-60, 25 figs.

LONDON:
PUBLISHED BY THE SOCIETY AND
SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 3s. 6d.

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Founded, 1833. Incorporated by Royal Charter, 1885.

PATRON—HIS MAJESTY THE KING.

OFFICERS and COUNCIL for the SESSION, 1946–1947.

PROF. G. D. HALE CARPENTER, M.B.E., D.M., *President*.

W. J. HALL, D.Sc.
C. B. WILLIAMS, M.A., D.Sc. } *Vice-Presidents*.
H. B. WILLIAMS, LL.D.

A. WELTI, *Treasurer*.

N. D. RILEY, *Secretary*.

Other Members of Council.

C. H. ANDREWES, F.R.S.

J. W. EVANS, M.A., D.Sc.

G. FOX-WILSON, N.D.H.

R. M. GREENSLADE.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

CAPT. R. A. JACKSON, R.N.

MISS C. E. LONGFIELD.

SIR GUY A. K. MARSHALL, K.C.M.G.,

D.Sc., F.R.S.

G. E. J. NIXON, B.A.

J. F. PERKINS, B.Sc.

F. J. GRIFFIN, A.L.A., *Registrar*.

Finance and House Committee.

G. FOX-WILSON, N.D.H. (Chairman).

J. W. EVANS, M.A., D.Sc.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

W. RAIT-SMITH.

O. W. RICHARDS, M.A., D.Sc.

Publication and Library Committee.

W. J. HALL, D.Sc. (Chairman).

H. E. HINTON, B.Sc., Ph.D.

B. M. HOBBY, M.A., D.Phil.

J. F. PERKINS, B.Sc.

J. SMART, B.Sc., Ph.D.

W. H. THORPE, M.A., Sc.D.

Committee on Generic Nomenclature.

FRANCIS HEMMING, C.M.G., C.B.E. (Chairman).

W. A. F. BALFOUR-BROWNE, F.R.S.E.

K. G. BLAIR, D.Sc.

O. W. RICHARDS, M.A., D.Sc.

N. D. RILEY (Secretary).

Committee for the Protection of British Insects.

H. M. EDELSTEN, O.B.E. (Chairman).

R. B. BENSON, M.A.

E. A. COCKAYNE, M.A., M.D., F.R.C.P.

CAPT. R. A. JACKSON, R.N.

COL. F. A. LABOUCHERE.

A. M. MASSEE, D.Sc.

THE HON. MIRIAM ROTHSCHILD.

W. H. THORPE, M.A., Sc.D.

N. D. RILEY (Secretary).

The Executive Officers of the Society are *ex-officio* members of all Committees.

DELEGATES OF THE SOCIETY TO:

1. **British National Committee for Biology** (Royal Society).

Sir Guy A. K. Marshall, K.C.M.G., D.Sc., F.R.S., appointed 1939.

Dr. V. B. Wigglesworth, M.A., B.Ch., M.D., F.R.S., appointed 1943.

2. **Local Committee of Management of Wicken Fen.**

Mr. H. M. Edelsten, O.B.E. [nominated by Committee for the Protection of British Insects].

3. **National Trust for Places of Historic Interest or Natural Beauty.**

Mr. H. M. Edelsten, O.B.E., appointed 1944.

4. **New Forest Association.**

Mr. W. Fassnidge, appointed 1934.

5. **New Forest Joint Committee.**

Mr. W. Fassnidge, appointed 1939. Dr. F. J. Killington, D.Sc., A.L.S., appointed 1939.

6. **Royal Meteorological Society. Phenological Committee.**

Dr. C. B. Williams, M.A., D.Sc., appointed 1937.

7. **Biology War Committee.**

Prof. P. A. Buxton, M.A., F.R.S., appointed 1941.

8. **Council for the Promotion of Field Studies.**

Dr. W. H. Thorpe, M.A., Sc.D., appointed 1944.

9. **Joint Bioclimatic Committee.**

Dr. B. P. Uvarov, C.M.G., D.Sc., appointed 1945.

Dr. C. B. Williams, M.A., D.Sc., appointed 1945.

A NATURAL CLASSIFICATION OF LEAF-HOPPERS (JASSOIDEA, HOMOPTERA)

PART 1.

EXTERNAL MORPHOLOGY AND SYSTEMATIC POSITION.

By J. W. EVANS, M.A., D.Sc.

(*Imperial Institute of Entomology.*)

Manuscript received 1st January, 1945.

(Read 2nd May, 1945.)

WITH 25 TEXT-FIGURES.

SINCE the time when attention was first paid to insects as plant pests, the injurious nature of the feeding activities of leaf-hoppers has been well known. It is only of recent years, however, that full realisation has been possible of the true importance of these insects. This is because it is now known that in addition to causing direct injury to growing plants by the removal of their sap, many species are also vectors of virus diseases of plants.

As well as being an important group of insects from the economic aspect, leaf-hoppers can claim attention for other reasons. One such reason is their age, and it is probable that they have changed but little since late Palaeozoic times.

Their classification presents great difficulties, largely because they are, on the whole, a homogeneous group and lack well-defined characters in many of the middle categories.

Several systems of classification have been proposed at different times, notably those of Baker (1923) and Haupt (1929), but none has secured general acceptance. My views on the classification of leaf-hoppers (Evans, 1939b; 1941c) differ widely from those of other workers and as at present it seems probable that my task in the future will be to describe a large amount of new material, it may prove helpful to those who follow if I present a full account of them.

Leaf-hoppers, although an old group of insects, which retain certain primitive characteristics lost in other Orders, are also, in certain respects, extremely specialised.

For reasons which will become apparent, the system to be outlined cannot be explained by means of keys. Instead, illustrations will be used; and it is hoped that these will make possible the assignment of any leaf-hopper to its correct position in a natural classification.

As a preliminary, some appreciation of the structure of these insects is necessary, primarily because systematic studies are to a large extent applied comparative morphology, but also because confusion might otherwise arise between instances of convergence and true relationship.

The purpose of the present paper, which is the first in a series, is to offer an interpretation of certain controversial points concerned with the structure of the head, to illustrate and describe the external morphology of a representative species and to discuss the position of leaf-hoppers with respect to the rest of the Homoptera-Auchenorrhyncha. In succeeding papers of the series an attempt will be made to describe and illustrate the principal diagnostic features of every

distinct natural group and at the same time to place in its correct group as many genera as possible of those which have already been described, and which total approximately 1000.

The Structure of the Head.

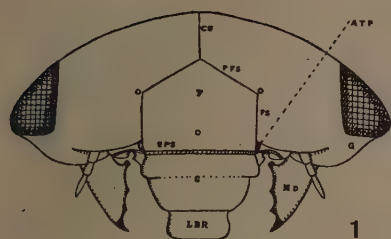
Fig. 10 represents the head of a leaf-hopper (*Putoniessa nigra* Walk.). Attention is drawn to the three median sclerites, the most anterior of which is a small triangular lobe which projects beyond the margin of the head-capsule. A student commencing descriptive work and wishing to learn how to name these structures correctly will, on referring to the established literature, become extremely puzzled. Snodgrass (1935 : 330, fig. 177c) refers to them as the clypeus, ante-clypeus and labrum respectively and Imms (1934 : 348, fig. 346) as the clypeus, labrum and epipharynx. On turning for enlightenment to works dealing exclusively with the Hemiptera, his confusion will increase. Thus Haupt (1929 : 180, fig. 4) names the two anterior median sclerites of a fulgoroid the labrum. Posterior to these is a part he calls the clypeus, while to the large median plate lying between the eyes he gives the name vertex. Spooner (1938) names the hind part of the large median plate in leaf-hoppers the frons, and the part immediately anterior to the antennae the post-clypeus; while the rectangular sclerite is called by him the ante-clypeus and the small triangular one the labrum. I have done likewise except that I have employed the term fronto-clypeus for the whole of the large sclerite in leaf-hoppers and the term frons for Haupt's vertex in fulgoroids (Evans, 1938).

Ferris (1943) denies the occurrence of an unpaired median plate posterior to the clypeus in any insect. He suggests that the term "frons" signifies nothing more than the facial portion of the antennal segment, and that frontal sutures have no existence in fact. By "frontal sutures" are meant sutures which lie between the antennae and which extend anteriorly from the apices of the epicranial (or postfrontal) sutures as far as the epistomal (or clypeo-frontal) suture (Snodgrass, 1935 : fig. 35).

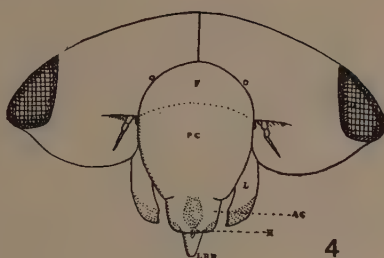
Attention is next directed to a pair of plates shown in fig. 10, which lie on each side of the median sclerites. These have been claimed to be of mandibular origin (Smith, 1892); to be part of the genae (Muir, 1926); to be part of the clypeus (Spooner, 1938; Evans, 1938); to be part of the hypopharynx (Snodgrass, 1938; Butt, 1943); and to belong to the antennal segment (Ferris, 1943). Other debated points concerned with the head are the extent of the maxillae and the position of the pits of the anterior arms of the tentorium. Finally, confusion often exists in descriptive work because the terms "crown" and "vertex" are used as if they were synonymous.

I suggest that among the Pterygota the most primitive type of insect development is to be found among the larvae of the Mecoptera and the Sialioidea (Megaloptera). This is because the Mecoptera and Sialioidea lie at the base of the Holometabola and have polypod larvae, which represent an earlier onto-

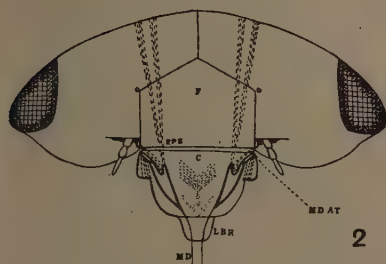
Figs. 1-9.—Illustrations of steps leading to the development of the jassid head. AC., ante-clypeus; AT., anterior arms of the tentorium; ATP., anterior tentorial pit; C., clypeus; CLS., clypeal suture; CS., coronal suture; EPS., epistomal suture; F., frons; FS., frontal suture; H., hypopharynx; L., lorum; LAB., labium; LABAP., labial apodeme; LABR., labial retractors; LABRP., labial protractors; LBR., labrum; MA., maxillary stylet; MAPR., maxillary protractors; MAR., maxillary retractors; MD., mandibular stylet; MDAT., attachment of mandibular stylet to head capsule; MDP., mandibular protractors; MDR., mandibular retractors; MP., maxillary plate; PC., post-clypeus; PT., posterior arms of tentorium; SALAP., apodeme for reception of muscles of salivary pump; SALPMP., salivary pump.



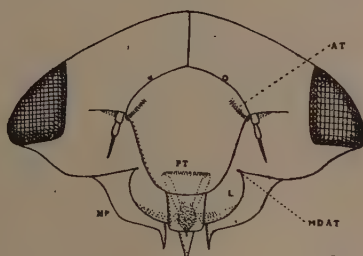
1



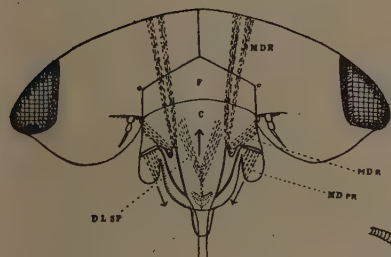
4



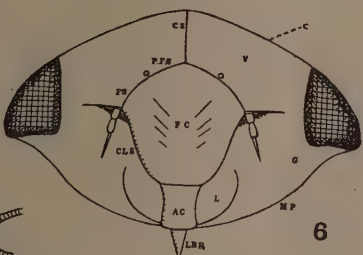
2



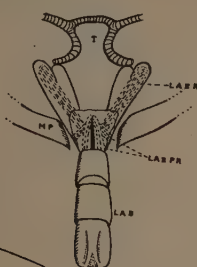
5



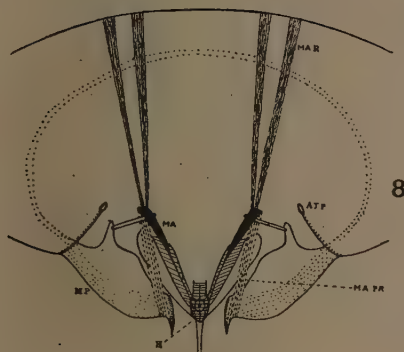
3



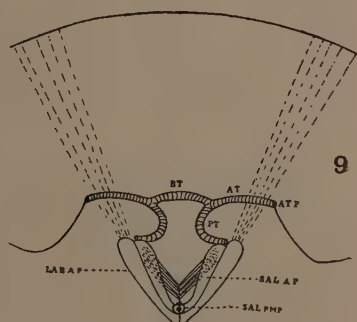
6



7



8



9

genetic stage than the post-oligopod nymphs of the Hemimetabola. Illustrations of the heads of such larvae have been given in several recent papers. Ferris (1942 : fig. 21) figures the head of a corydalid, and Cook (1943 : fig. 7) reproduces the same figure. Applegarth (1939) figures the head of a mecopter and Evans (1942) the heads of a mecopter and a corydalid. All these heads have a feature in common. This is the presence of a median unpaired sclerite similar to that shown in fig. 1. This sclerite is bounded posteriorly by an inverted V-shaped suture and laterally by a pair of sutures which extend anteriorly as far as the lateral margins of the clypeus. In the mecopter larva figured by Evans there is a transverse suture which forms the anterior boundary of the sclerite. Close to the apices of this transverse suture are the pits of the anterior arms of the tentorium, and the antennae are at the sides of the head, more or less in line with the pits. The heads of corydalid larvae lack a transverse suture between the pits, and the anterior boundary of the median sclerite lies well in front of the antennae. Such a suture is, however, present in the heads of the sialid larvae (e.g. *Sialis lutaria*).

Fig. 1 is a reconstruction of a hypothetical insect head which is identical in essentials with the head of the larval mecopter figured previously. The median unpaired sclerite is the frons which is bounded posteriorly by the post-frontal sutures, laterally by the frontal sutures, and anteriorly by the epistomal suture. The epistomal suture separates the frons from the clypeus, and the anterior tentorial pits lie close to its apices. Such an unpaired median sclerite occurs in the heads not only of larval Mecoptera, corydalids and sialids, but also in certain larval Coleoptera and in larvae belonging to other Orders. It also occurs in several Homoptera, notably in the Fulgoroidea, but also in the psyllid, *Paurocephala magnifrons* (Crawford, 1914), the nymphs of *Tartessus* spp. (JASSIDAE) and the nymphs of *Hemiodocus* spp. (Evans, 1937, 1941c; Snodgrass, 1938; Ferris, 1943).

I have suggested in an earlier paper (1942) that in corydalids that part of the median plate posterior to the tentorial pits is the frons, the clypeus being the part anterior to the pits. Ferris (1942) and Cook (1943) believe that in corydalid and mecopterous larvae the whole of the median plate belongs to the clypeus, although, as already pointed out (Evans, 1943), in adult corydalids the median ocellus occurs on this sclerite. Similarly in *P. magnifrons* and certain fulgoroids, the median ocellus occurs on a well-defined central frons.

Consider now the head of a leaf-hopper (JASSIDAE). The following features are noted in fig. 6 : posteriorly a median longitudinal suture, the coronal suture; and centrally a large sclerite bearing muscle impressions, bounded posteriorly by a pair of divergent sutures which extend as far as the antenna on each side. Close to, and midway along these latter sutures, are the ocelli and at right-angles to their terminations, near the antennae, is a pair of transverse ledges which overhang the antennae. These ledges are a very constant feature of the Homoptera-Auchenorrhyncha, with the exception of the Fulgoroidea. Directly anterior to the large central sclerite is a smaller rectangular one, on either side of which is a pair of rounded flaps. If the rectangular plate is raised, so that it is attached to the head only at its posterior margin, it will be found that the lateral flaps continue in a medial direction underneath it and are attached to the sides of a ventral bowl-shaped depression (fig. 12). On either side of these flaps is a pair of plates which extend from the eyes and the antennae as far as the anterior margin of the head. Finally there is a small anteriorly-projecting lobe.

An attempt will now be made to trace certain steps which have led to the

development of the type of head shown in fig. 6 from some such type as that illustrated in fig. 1.

The hypothetical head shown in fig. 1, while agreeing with the head of the mecopterous larva figured previously in the presence of the coronal suture and in the position of the frons, eyes, antennae, anterior tentorial pits, anterior mandibular articulations and post-antennal ledges, differs in having two additional features. These are the presence of paired ocelli close to the posterior corners of the frons and the partial sub-division of the clypeus. The position of the ocelli in the figure is their actual position in the majority of leaf-hoppers; any other position is a secondary development. A division of the clypeus, as indicated, is found commonly among the Orthoptera as well as in other Orders.

The sole articulations of the mandibles of certain Thysanura (*Machilis*) are at the back of the head, on the mandibular segment. Mandibulate pterygote insects have two articulations; a primary one on the mandibulate segment and a secondary one close to, or on, the posterior lateral corners of the clypeus. In heads which retain primitive features the actual anterior condyle of the mandible fits into a depression on a small plate, termed by Ferris (1943) the "paraclypeal lobe." The suture limiting this plate posteriorly, Ferris terms the "tentorial suture." These plates, according to Ferris, are not parts of the clypeus but belong to the antennal segment. He further states that their origin is obscure and suggests that the lora of Homoptera (fig. 6, L) are derived from them.

In all Homoptera the sole points of contact of the mandibular stylets with the head capsule are at the posterior inner angle of each lorum (fig. 13). In fig. 2 the hypothetical first stage of the development of the lora is represented. The points of attachment of the mandibular stylets correspond to the anterior articulations of the mandibles as shown in fig. 1, only the epistomal suture now separates the anterior tentorial pits from the attachments of the mandibles and the latter are placed on the inner corner of the clypeus. In the nymphs of *Hemiodoeus* the pits are close to the posterior corners of the clypeus. Muir and Kershaw (1921) have shown that in the head of *Siphanta acuta* (Fulgoroidea) the frons, clypeus and labrum are not separated from each other by transverse sutures at an early embryological stage. Possibly they are all derived from the primitive prostomium and the epistomal suture is a secondary fold which developed in the first place as a direct result of the acquisition of the anterior articulations of the mandibles. While this suture, which encloses a thickened fold, serves to give added strength to the anterior part of the head capsule of biting insects, its loss in many Homoptera can be associated with the acquisition of piercing mandibles and the change in the position of their attachment.

If fig. 3 is compared with fig. 2, it will be noted that the epistomal suture and the antennal ledges, which are derived from the tentorial sutures, have been shifted in a posterior direction. I suggest that this backward development of the clypeus which is accompanied by a reduction in the size of the frons, a development found also in cicadas and cercopids, is the direct result of the backward pressure of the dilator muscles of the sucking-pump, together with those of the mandibular-tentorial retractor muscles. I wish to stress the fact that the direction of the extension of the sclerite is the same as the direction of the pressure of the muscles inserted on its surface. In direct apposition to these retractor muscles and to those mandibular muscles which are inserted on the base of the head capsule are the protractor muscles of the mandibles. The pressure exerted by these is in the direction of the front of the head.

It is now possible to suggest the probable course of development from a type of head such as that illustrated in fig. 1 to a type resembling fig. 6 as far as the

frons, clypeus, labrum and lora are concerned. In the change from biting to piercing mandibles the functions of the original abductor and adductor muscles changed to those of protractors and retractors. This change resulted in the abductors assuming a reversal of direction from the posterior to the anterior part of the head (Börner, 1929). If, as is here assumed, the protractors became attached to the sides of the clypeus, the effect of their pressure may well have resulted in the development of lateral clypeal lobes, as shown in fig. 3. At the same time the clypeus increased in size posteriorly and the frons and labrum decreased in size. In fig. 4 the epistomal suture has almost disappeared and the clypeal lobes have lengthened and have been cut off at their bases by the backward extension of the sides of the clypeus. In addition a new transverse suture has partially appeared, which separates the anterior part of the clypeus, overhanging the sucking-pump, from the posterior part bearing the dilators of the sucking-pump. It is not suggested that the clypeal lobes ever hung free as shown in fig. 4, but that they were directed inwards, in the direction of the pull of the protractors of the mandibles, and that the development of the new transverse suture was contemporaneous with their attachment to the sides of the base of the hypopharynx (ventral surface of the sucking-pump).

The final stages, as shown in figs. 5 and 6, were probably the completion of the transverse sutures separating the ante- from the post-clypeus, the fusion of the bases of the clypeal lobes with the anterior margins of the genae, the complete obliteration of the epistomal suture (consequent on the backward migration of the cibarial dilators on to the frons), and the loss of the separate identity of the postfrontal and frontal sutures.

This hypothesis is based on several facts. In several fulgoroids, as shown by Spooner, and in *Hemiodocus*, there is a complete frons as illustrated in fig. 2. Further, not only is the ante-clypeus not separated from the post-clypeus by a transverse suture, but also the lora are not separated postero-laterally from the rest of the clypeus. Also, the tentorial pits in *Hemiodocus* are on the sides of the clypeus, close to the ends of the epistomal suture. The Fulgoroidea are the most primitive group of the Auchenorrhyncha and the PELORIDIIDAE are undoubtedly the most primitive surviving Homoptera (Evans, 1937, 1939a, 1941a). In addition, a few leaf-hoppers have a complete frons in their nymphal stages and many retain traces of a frons when adult.

I do not accept the suggestion of Snodgrass that the lateral parts of the hypopharynx, on which in Orthoptera muscles of the mandibles are attached, have been expanded in Hemiptera to form the loral plates. My reason for disagreeing on this point is that it involves the growth of the lora in a direction contrary to the pull of the mandibular retractors.

That the lora are not part of the mandibles has been shown by the embryological studies of Muir and Kershaw. Ferris' suggestion that they are developments of the paraclypeal lobes of mandibulate insects is difficult to understand, because according to my interpretation, the ledges overhanging the antennae are derived from the continuation of the suture termed by Ferris the "tentorial suture." In this connection the position of the anterior pits in fig. 13 should be noted and this figure compared with figs. 2 and 3. The area immediately anterior to the antennae on each side would thus seem to correspond with the paraclypeal lobes of Ferris. There is, however, a further possibility to consider. In the mecopteran larva figured earlier (Evans, 1942) I have shown that the epistomal fold continues beyond the apices of the frontal sutures as far as the antennae on each side. The anterior tentorial pits are posterior to the lateral continuations of the fold and the articulations of the

mandibles are anterior to it. In the mecopteran, a suture (the continuation of the frontal suture) separates the mandibular articulations from the clypeus, but in the larva of *Sialis lutaria* no such suture exists. In other words, that part of Ferris' paraclypeal lobes, on which the mandibles articulate, has become incorporated in the clypeus. Hence the lora may in part be of paraclypeal origin.

Finally, that the lora cannot be derived from the gena is evident from the fact that the genae of Homoptera are secondary developments and cannot have formed part of the ancestral head capsule.

The maxillae have been omitted from figs. 1-4 but are shown in figs. 5, 6 and 8. In the Sternorrhyncha, Coleorrhyncha (PELORIDIIDAE) and certain Auchenorrhyncha, the maxillary plates either have no contact with the face of the head or are attached to the genae but are not completely fused with them (fig. 5). Fig. 8 shows the relation of the maxillary stylets and the maxillary plates to the rest of the head before the development of their association with the genae.

In fig. 9 the tentorium is shown as it occurs in the PELORIDIIDAE and as it is assumed to have been in the stages of development reproduced in figs. 2 and 3. The backward movement of the frons and antennae will have been accompanied by the backward shifting of the pits of the anterior arms. While in fulgoroids, cicadas and cercopids this movement was accompanied by a progressive lengthening of the anterior arms, the same effect did not occur in jassids. Instead the anterior arms lost contact with the posterior arms. The final result is illustrated in fig. 5, where the anterior arms are short and have no connection with the posterior arms. The latter consist of a transverse strut joining the apices of a pair of apodemes which arise from the base of the hypopharynx and on which are inserted the dilator muscles of the salivary syringe. In addition to these hypopharyngeal apodemes there is also another pair, and the two pairs are in close association with one another. The second pair supports the retractors of the labium distally and also one set of labial protractors, close to the point where they arise from the labium. The other set of protractors is inserted on the base of the labium itself (fig. 7). Although in some Homoptera the apophyses of the hypopharynx dwarf those of the labium, the two pairs are quite distinct in leaf-hoppers.

Before turning to the description of the structure of an actual leaf-hopper, it is desirable to explain the terms used to describe the various parts of the jassid head in fig. 6.

That part of the head which is visible from above and is on a plane with the pronotum is the crown. The term has no morphological significance, and may comprise part of the frons and part of the post-clypeus as well as part of the vertex. In facial aspect the coronal suture divides the vertex longitudinally as far as the point of divergence of the arms of the epicranial suture, here called the postfrontal suture. The lateral apices of the postfrontal sutures are usually close to the ocelli. The frontal sutures are a continuation of the postfrontal sutures as far as the antennae. Two terms are necessary to describe what might appear to be a single suture. This is because in some forms one pair is lost and in other forms the other pair is not developed. That part of the median sclerite posterior to the antennal ledges is of frontal origin, but because the muscles of the sucking-pump may extend on to its inner surface the whole plate is termed the "fronto-clypeus." The suture bordering the post-clypeus, from the antennae as far as the ante-clypeus, is termed the "clypeal suture." The other terms used, lorum, maxillary plate and labrum, need no comment.

The External Morphology of a Leaf-hopper (*Putoniessa nigra* Walker).

Many works exist in which some mention is made of the morphology of leaf-hoppers. In some the insect is dealt with as a whole; in others a comparative study is made of a single part. Nevertheless, the need still exists for further studies of the structure of representative Homoptera. The present study is not intended to be complete but is intended to serve three purposes: namely, to demonstrate the musculature of the stylets; to explain the venation

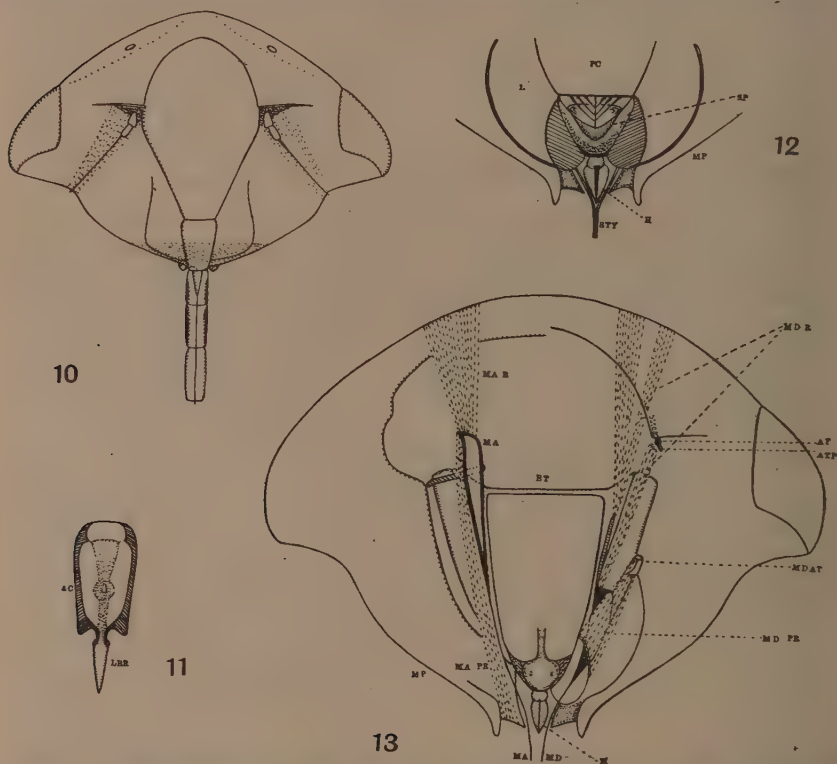


FIG. 10.—Head of *Putoniessa nigra*. FIG. 11.—Epipharyngeal surface of ante-clypeus and labrum. FIG. 12.—Anterior part of head after removal of ante-clypeus and labrum. FIG. 13.—Head, showing musculature of maxillary and mandibular stylets. AF., antennal foramen; BT., body of tentorium; SP., dorsal surface of sucking-pump; STY., stylets; other lettering as in figs. 1–9.

of the tegmen, and to compare it with the venational plan of certain other leaf-hoppers; and to describe the structure of the rest of the body in order to draw attention to certain primitive features.

The Head.

The complete head in facial aspect is illustrated in fig. 10. It will be noted that the ocelli do not retain their primitive position. Fig. 11 represents the epipharyngeal surface of the ante-clypeus and labrum, and fig. 12 the anterior part of the head after the removal of the ante-clypeus and labrum. The cone-

shaped structure shown in fig. 12 is the dorsal surface of the sucking-pump. The insertions of the dilator muscles of the sucking-pump (the cibarial muscles) are on its inner surface, and their distal attachments are on the fronto-clypeus. The ventral surface of the sucking-pump is the U-shaped trough from which the anterior lobe of the hypopharynx is suspended. The lora are attached to the sides of the trough on each side. The salivary syringe is enclosed by the hypopharynx and the salivary duct opens at its apex, where it makes contact

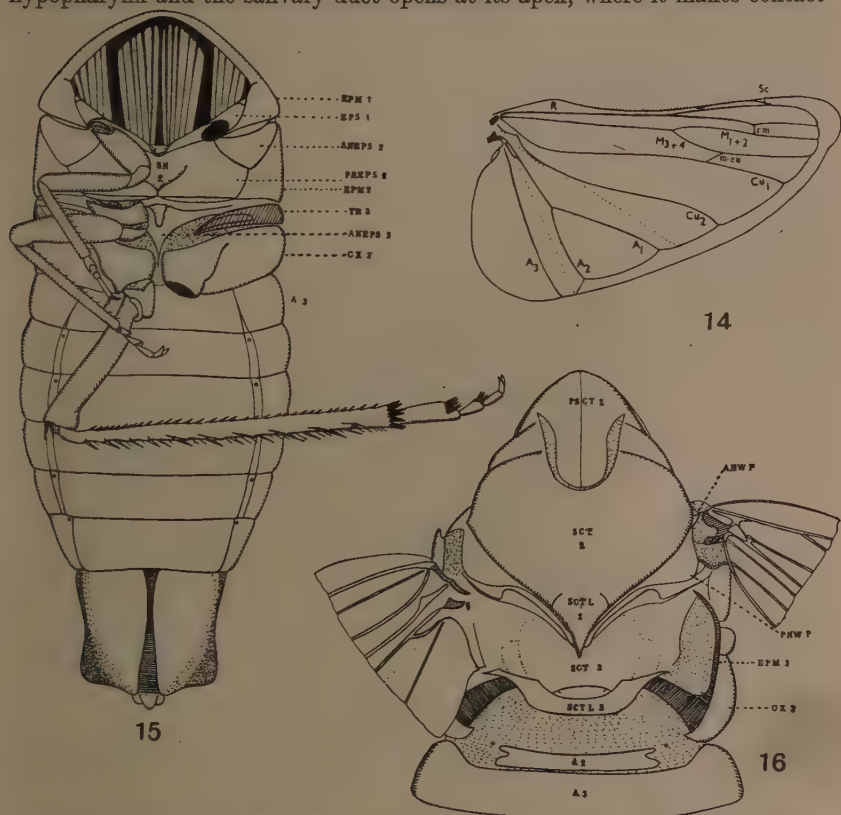


FIG. 14.—*P. nigra*, wing. FIG. 15.—*P. nigra*, thorax and abdomen, ventral aspect. FIG. 16.—*P. nigra*, meso- and meta-thorax and part of abdomen, dorsal aspect. A., abdominal segment; ANEPS., anepisternum; ANWP., anterior notal wing process; CX., coxa; EPM., epimeron; EPS., episternum; PNWP., posterior notal wing process; PREPS., pre-episternum; PSCT., pre-scutum; SCT., scutum; SCTL., scutellum; SN., sternum; TR., trochantin.

with the apposed stylets. The musculature of the mandibular and maxillary stylets is shown in fig. 13, the head being viewed in facial aspect. Comment on this figure is unnecessary.

The Thorax and Abdomen.

Fig. 15 illustrates *P. nigra* in ventral aspect, the head having been removed. The muscles shown are the median dorsal longitudinal muscles of the tegmina

and laterally the coxal muscles of the fore legs. The dorsal surface of the prothorax consists of an undivided plate, the pronotum. Laterally and ventrally the episterna are reduced and the visible sternum small, although the pits of the sternal apophyses are widely separated. The apophyses are fused at their extremities with processes arising from the pleural sutures.

In the mesothorax each episternum is divided into an anepisternum and a pre-episternum, the epimera are undivided and the sternal apophyses arise from paired invaginations situated at the sides of the triangular sternum.

In the metathorax the trochantins and hind coxae are enormously enlarged, a development associated with the use of the hind legs for jumping. The episterna and epimera are concealed by the coxae. The epimera extend around the leg bases and, together with the post-coxale on each side, they form strong

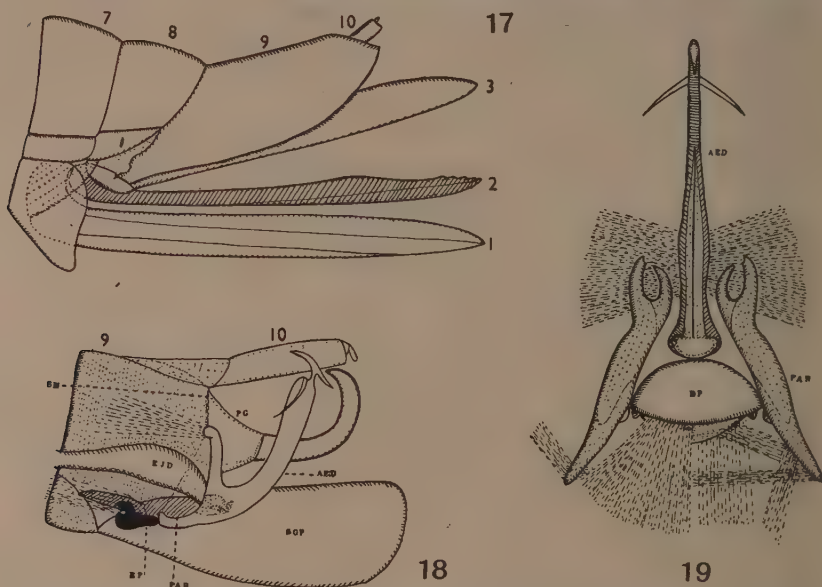


FIG. 17.—*P. nigra*, female genitalia. FIG. 18.—*P. nigra*, male genitalia. FIG. 19.—Aedeagus, parameres and basal plate, dorsal aspect. AED., aedeagus; BP., basal plate; EJD., ejaculatory duct; PAR., paramere; PG., pygophore; SM., segmental membrane.

struts which meet just behind the sternal invaginations. The sternal apophyses are short and arise from a single pit.

The mesonotum and part of the metanotum are shown in fig. 16, which also shows the axillary sclerites and the bases of the fore- and hind-wings. The area anterior to the U-shaped suture (which separates the attachments of the median dorsal longitudinal muscles from the tergo-sternal muscles of the tegmina) is called the pre-scutum in the figure. As I have explained in a previous paper (Evans, 1941b), in reference to the cicada *Tettigarcta tomentosa*, it is uncertain whether all this area or just that part anterior to the first pair of transverse folds belongs to the true pre-scutum. The post-notum of the mesothorax is concealed beneath the scutum and scutellum and its phragma support the lateral dorsal wing muscles. The post-notum of the metathorax

is reduced and hidden by the meta-scutellum, and the meta-pleural epimera are joined to it on each side by strong processes which lie immediately posterior to the wing bases.

The spines on the hind tibiae, as in many leaf-hoppers, are in four distinct rows; one row of spines is hair-like and another row is mounted on enlarged bases. The other two rows consist of widely-spaced long spines and closely set small spines respectively. (The venation of the tegmen (fig. 25) and of the wing (fig. 14) will be discussed in a later section.)

The first abdominal segment is reduced and its tergum is concealed by the scutellum of the metathorax. The spiracles shown in fig. 16 belong to the second abdominal segment, which is also reduced.

The female genitalia (fig. 17) are structurally identical with the type common to all the Auchenorrhyncha, with the exception of certain Fulgoroidea. According to Snodgrass (1935), the three pairs of valvifers of the ovipositor of Homoptera more nearly retain their original segmental connections than they do in other Orders. No purpose would be served by describing the various parts of the ovipositor, since these are clearly shown in the figure, and Snodgrass' account of the ovipositor of a cicada applies equally to that of a leaf-hopper.

The male genitalia are illustrated in figs. 18 and 19. Attention is drawn to the attachment of the aedeagus and that of the parameres (harpogones) to the basal plate. In *P. nigra* the separate identity of the sternum of the ninth segment is retained; it is lost in many leaf-hoppers. The large clasper shown in the figure lying between the tenth (anal) segment and the sub-genital plate is a process of the pygophore. Accessory clasping organs, associated either with the pygophores or the sub-genital plates, are of frequent occurrence in leaf-hoppers.

The Position of Leaf-hoppers within the Homoptera-Auchenorrhyncha.

This series of papers will be concerned only with leaf-hoppers, but as a preliminary some attention must be given to their relationships with other groups of Homoptera.

The usual practice is to start with two primary divisions of the Auchenorrhyncha, one comprising the Fulgoroidea and the other all the remainder. While acknowledging the very wide gap which separates the Fulgoroidea from the other groups, I consider that it is misleading to associate the cicadas so intimately with the cercopids, jassids and membracids. Hence a primary separation into three divisions, instead of two, is proposed.

1. Tegulae almost always present; middle coxae elongate, articulated far apart, free and capable of lateral movement; hind coxae immobile; wing without a marginal vein Fulgoromorpha.
- Tegulae absent; middle coxae short, articulations near together; hind coxae mobile; wing with a marginal vein 2.
2. Head with a swollen post-clypeus, the crown with a small triangular frons bearing a median ocellus Cicadomorpha.
- Head with a large, but not necessarily swollen post-clypeus, which may or may not be distinct from the frons; frons without a median ocellus Jassidomorpha.

The next step is the sub-division of the Jassidomorpha into two superfamilies:—

- In the head, the anterior arms of the tentorium fused with the posterior arms; hind coxae short, conical, not transversely dilated; hind tibiae with one or a few strong spurs but lacking spines Cercopoidea.

(1926) and myself (1943) with respect to fossil Homoptera, suggests that R_s is always unbranched in jassids.

Figs. 22-24 represent the tegmina of *Aethalion reticulatum* L. (AETHALIONIDAE), *Balala fulviventris* Dist. (HYLICIDAE) and *Eurymeloides bicincta* Erichs. (EURYMELIDAE) respectively. The tegmen of *A. reticulatum* differs from the jassid type in the absence of R_s , the extension of M_{1+2} to the apex of the tegmen, the presence of M_3 and M_4 as separate veins and the unbranched condition of Cu_1 . All known representatives of this family share these characteristics, except that in *Darthula hardwicki* Gray, from Southern India, all four branches of the media are distinct.

The HYLICIDAE, represented here by *B. fulviventris*, have not in the past received the attention their interest merits. The venation illustrated in fig. 23 differs from the jassid type in having M_{1+2} extending to the apex of the tegmen and M_{3+4} fused apically with Cu_{1a} . This involves the suppression of cross-vein $m-cu_3$. The wide apical appendix is a further constant characteristic and attention is drawn to the presence of a nodal line.

The tegmen of the eurymelid (fig. 24) differs from fig. 25 in the absence of R_s and in the extension of M_{1+2} to the apex of the tegmen.

The same stability in basic tegminal venation does not occur in the MEMBRACIDAE. Thus M may be fused basally either with R or with Cu_1 . Funkhouser (1913) was of the opinion that Cu_1 was unbranched in the MEMBRACIDAE. As a result of a study of his figures of tracheation and venation and of the examination of a wide range of material, including *Nicomia cicadoides* Walk. from British Guiana, I suggest that Cu_1 has two branches in membracids, as in other jassoid families, apart from the AETHALIONIDAE.

Fig. 21 represents the venation of a hypothetical form which could serve as a common ancestor to the four types illustrated in figs. 22-25, and fig. 20 represents the tegmen of *Homaloscytina plana* Tillyard, from the Upper Permian of New South Wales. The two figures differ from each other in the following features: the wide costal space of *H. plana* is lacking in fig. 21; R and M are not completely fused basally in *H. plana* as they are in fig. 21; cross-vein $m-cu_3$ is absent in *H. plana* and present in fig. 21.

Homaloscytina plana belongs to the family SCYTINOPTERIDAE, a family of Permian Homoptera from which it is probable that both the Jassoidea and Cercopoidea have been derived. The hind-wings of scytinopterids lacked a marginal vein, which is therefore probably a secondary development. Fig. 14 represents the wing of *P. nigra*. It will be noticed that the two branches of R are not labelled in the figure. This is because it is uncertain whether they represent R_{2+3} and R_{4+5} , as suggested by Metcalf, or R_1 and R_s as would seem more probable.

ACKNOWLEDGEMENTS.

My interest in the Homoptera first developed in 1927 as a result of seeing cicadas for the first time, in New Zealand, and in 1928 I got in touch with Mr. W. E. China, of the British Museum. During the many years which have passed since 1928 I have worried Mr. China with innumerable queries, seeking information concerned with the literature, requesting drawings of types and enlightenment on obscure points, and I have always received the help I sought. Mr. China has further placed at my disposal, for use in the present study, a list he has compiled, but never published, of all the jassid genera of the world, together with their genotypes. Grateful acknowledgement is made of all the assistance which has been so generously given. Without that assistance this

contribution to our knowledge of leaf-hoppers could never have been made. I am also grateful to Dr. T. H. C. Taylor for assistance in the final preparation of this paper for the press.

REFERENCES.

- APPLEGARTH, A. G., 1939, The Larva of *Apterabittacus apterus*. *Microentomology* 4 : 109.
- BAKER, C. F., 1923, The Jassoidea related to the STENOCOTIDAE. *Philip. J. Sci.* 22 : 345.
- BÖRNER, C., 1929, Mandibeln und Maxillen bei Psociden, Thysanopteren und Rhynchoten. *Z. wiss. InsBiol.* 24 : 108.
- BUTT, F. H., 1943, Comparative Study of the Mouth Parts of Representative Hemiptera-Homoptera. *Mem. Cornell Univ. agric. Exp. Sta.* 254.
- CARPENTER, F. M., 1933, Lower Permian Insects of Kansas, Pt. 6. *Proc. Amer. Acad. Arts Sci.* 68.
- COOK, E. F., 1943, The Heads of some Coleoptera. *Microentomology* 7 : 25.
- CRAWFORD, D. L., 1914, A Monograph of the PSYLLIDAE of the New World. *Bull. U.S. nat. Mus.* 85.
- EVANS, J. W., 1937, A new species of PELORIDIIDAE from Tasmania. *Proc. R. ent. Soc. Lond. (B)* 6 : 107.
- , 1938, The Morphology of the Head of Homoptera. *Pap. roy. Soc. Tasm.* 1938 : 1.
- , 1939a, The Morphology of the Thorax of the PELORIDIIDAE. *Proc. R. ent. Soc. Lond. (B)* 8 : 143.
- , 1939b, A Contribution to the Study of the Jassoidea. *Pap. roy. Soc. Tasm.* 1939 : 19.
- , 1941a, Concerning the PELORIDIIDAE. *Austr. J. Sci.* 4 : 95.
- , 1941b, The Morphology of *Tettigarcta tomentosa*. *Pap. roy. Soc. Tasm.* 1941 : 35.
- , 1941c, The Inter-relationships of certain Jassoid genera. *Psyche* 48 : 113.
- , 1942, Further Notes on the Morphology of the Insect Head. *Trans. roy. Soc. S. Austr.* 66 : 180.
- , 1943, Upper Permian Homoptera from New South Wales. *Rec. Austr. Mus.* 21 : 180.
- FERRIS, G. F., 1942, Some Observations on the Heads of Insects. *Microentomology* 7 : 25.
- , 1943, The Basic Materials of the Insect Cranium. *Microentomology* 8 : 8.
- FUNKHOUSER, W. D., 1913, The Homologies of the Wing Veins of MEMBRACIDAE. *Ann. ent. Soc. Amer.* 11 : 225.
- HAUPT, H., 1929, Neueinteilung der Homoptera-Cicadina nach phylogenetisch zuwertenden Merkmalen. *Zool. Jahrb. (Syst.)* 58 : 173.
- IMMS, A. D., 1934, *A General Textbook of Entomology*. London.
- METCALF, Z. P., 1913, The Wing Venation of the JASSIDAE. *Ann. ent. Soc. Amer.* 6 : 74.
- MUIR, F., and KERSHAW, J. C., 1912, The Development of the Mouthparts in Homoptera with observations on the Embryo of *Siphanta*. *Psyche* 19 : 77.
- MUIR, F., 1926, Notes on the Head of the Cicada. *Ann. ent. Soc. Amer.* 19 : 67.
- SMITH, J. F., 1892, Notes on the Homology of the Hemipterous Mouth. *Proc. Amer. Ass. Adv. Sci.* 40 : 325.
- SNODGRASS, R. E., 1935, *Principles of Insect Morphology*. New York.
- , 1938, The Loral Plates and Hypopharynx of Hemiptera. *Proc. ent. Soc. Wash.* 40 : 228.
- SPOONER, C. S., 1938, The Phylogeny of the Hemiptera based on a Study of the Head Capsule. *Illinois biol. Monogr.* 26 (3).
- TILLYARD, R. J., 1926, Upper Permian Insects of New South Wales, Pt. 1. *Proc. linn. Soc. N.S.W.* 51 : 1.

MAY
Vol. 96. Part 4. Pp. 61-72, 25 figs.

30th April, 1946.

Eu. 344.

THE
TRANSACTIONS
OF THE
ROYAL
ENTOMOLOGICAL SOCIETY
OF
LONDON

World List abbreviation: Trans. R. ent. Soc. Lond.

CONTENTS

	PRICE
GARDNER, J. C. M., C.I.E., F.R.E.S. On larvae of the NOCTUIDAE (Lepidoptera)—I.	61-72, 25 figs.

LONDON:

PUBLISHED BY THE SOCIETY AND
SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 2s. 6d.

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Founded, 1833. Incorporated by Royal Charter, 1885.

PATRON—HIS MAJESTY THE KING.

OFFICERS and COUNCIL for the SESSION, 1946–1947.

PROF. G. D. HALE CARPENTER, M.B.E., D.M., *President*.

W. J. HALL, D.Sc.

C. B. WILLIAMS, M.A., D.Sc. } *Vice-Presidents*.

H. B. WILLIAMS, LL.D.

A. WELTI, *Treasurer*.

N. D. RILEY, *Secretary*.

Other Members of Council.

C. H. ANDREWES, F.R.S.

J. W. EVANS, M.A., D.Sc.

G. FOX-WILSON, N.D.H.

R. M. GREENSLADE.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

CAPT. R. A. JACKSON, R.N.

MISS C. E. LONGFIELD.

SIR GUY A. K. MARSHALL, K.C.M.G.,

D.Sc., F.R.S.

G. E. J. NIXON, B.A.

J. F. PERKINS, B.Sc.

F. J. GRIFFIN, A.L.A., *Registrar*.

Finance and House Committee.

G. FOX-WILSON, N.D.H. (*Chairman*).

J. W. EVANS, M.A., D.Sc.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

W. RAIT-SMITH.

O. W. RICHARDS, M.A., D.Sc.

Publication and Library Committee.

W. J. HALL, D.Sc. (*Chairman*).

H. E. HINTON, B.Sc., Ph.D.

B. M. HOBBY, M.A., D.Phil.

J. F. PERKINS, B.Sc.

J. SMART, B.Sc., Ph.D.

W. H. THORPE, M.A., Sc.D.

Committee on Generic Nomenclature.

FRANCIS HEMMING, C.M.G., C.B.E. (*Chairman*).

W. A. F. BALFOUR-BROWNE, F.R.S.E.

K. G. BLAIR, D.Sc.

O. W. RICHARDS, M.A., D.Sc.

N. D. RILEY (*Secretary*).

Committee for the Protection of British Insects.

H. M. EDELSTEN, O.B.E. (*Chairman*).

R. B. BENSON, M.A.

E. A. COCKAYNE, M.A., M.D., F.R.C.P.

CAPT. R. A. JACKSON, R.N.

COL. F. A. LABOUCHERE.

A. M. MASSEE, D.Sc.

THE HON. MIRIAM ROTHSCHILD.

W. H. THORPE, M.A., Sc.D.

N. D. RILEY (*Secretary*).

The Executive Officers of the Society are *ex-officio* members of all Committees.

DELEGATES OF THE SOCIETY TO :

1. British National Committee for Biology (Royal Society).

Sir Guy A. K. Marshall, K.C.M.G., D.Sc., F.R.S., appointed 1939.

Dr. V. B. Wigglesworth, M.A., B.Ch., M.D., F.R.S., appointed 1943.

2. Local Committee of Management of Wicken Fen.

Mr. H. M. Edelsten, O.B.E. [nominated by Committee for the Protection of British Insects].

3. National Trust for Places of Historic Interest or Natural Beauty.

Mr. H. M. Edelsten, O.B.E., appointed 1944.

4. New Forest Association.

Mr. W. Fassnidge, appointed 1934.

5. New Forest Joint Committee.

Mr. W. Fassnidge, appointed 1939. Dr. F. J. Killington, D.Sc., A.L.S., appointed 1939.

6. Royal Meteorological Society. Phenological Committee.

Dr. C. B. Williams, M.A., D.Sc., appointed 1937.

7. Biology War Committee.

Prof. P. A. Buxton, M.A., F.R.S., appointed 1941.

8. Council for the Promotion of Field Studies.

Dr. W. H. Thorpe, M.A., Sc.D., appointed 1944.

9. Joint Bioclimatic Committee.

Dr. B. P. Uvarov, C.M.G., D.Sc., appointed 1945.

Dr. C. B. Williams, M.A., D.Sc., appointed 1945.

ON LARVAE OF THE NOCTUIDAE (LEPIDOPTERA)—I

By J. C. M. GARDNER, C.I.E., F.R.E.S.

Manuscript received 15th February, 1945.

(Read 2nd May, 1945.)

WITH TWENTY-FIVE TEXT-FIGURES.

IN a previous paper (Gardner 1941, *Indian Forest Records (Ent.)* 6:8) an attempt was made to provide a practical key for the identification of a number of Indian Noctuid larvae with no definition of subfamily characters; since then I have reared many more species. In the present paper I have divided the larvae into what appear to be groups of closely related genera; these groups, although at least convenient for identification purposes, do not fully conform with the subfamilies of the adults as defined by Hampson (1901-1913, *Cat. Lep. Phalaenae*) and by Warren or Gaede in Seitz, *Macrolepidoptera of the World* (1912-1938); the larval groups are therefore referred to under symbols for the present.

The greater part of my larval material is from the Dehra Dun district and was reared mostly by field assistants Balwant Singh and S. L. Mark under my supervision. Only mature larvae are discussed, and it is probable that they are correctly associated with moths, and that the latter are correctly identified. Owing to war conditions it was not possible to communicate with specialists and most of the adults were identified by my assistant G. D. Bhasin. We have unfortunately not been able to identify many reared moths from literature; some of these are almost certainly new species. In this connection I must confess to considerable difficulty in forming a definite opinion as to the identity of some moths from published descriptions, and until more definite diagnoses based on adult structure, perhaps of the genitalia for example, can be given in the future, it appears often simpler to identify larvae.

Characters used. The characters of Noctuid larvae are discussed in Gardner 1941:255. Several genera have biordinal crochets and so are exceptional in the Noctuoidea but are typical Noctuids in other respects. In some genera the uniordinal mesoserries of crochets is heteroideous as in the ARCTIIDAE. The genus *Selepa* does not fit very well into the NOCTUIDAE (Gardner 1941:276). Characters of apparent major diagnostic value are: the position of seta III on A 8 in its relation to the spiracle; whether the ventral prolegs (on A 3 to A 6 inclusive) are of nearly equal size or not, and whether group VII on A consists of two or of three setae. Ripley (1923, *Illinois biol. Monogr.* 8 (4)) makes the important observation that group VII on the first abdominal segment consists of three setae in the CATOCALINAE, PHYTOMETRINAE and HYPENINAE, but of only two setae in other subfamilies such as the HADENINAE; this applies to most of the larvae seen by me but it is often difficult to determine. Most important diagnostic characters are found in the mandibles, the labrum, the spinneret, the crochets, and the texture of the skin: for all of these preparation for microscopic examination, a simple matter, is best, if not essential. I have not referred to certain minute setae nor, on this occasion, to the hypopharynx.¹

¹ Thoracic and abdominal segments are referred to as T 1-3 and A 1-10 respectively.

Each of the four groups of larvae now discussed seems quite sharply defined, groups A I, A IV and B II corresponding with the ACRONICTINAE, MELICLEPTINAE (with *Pyrrhia*) and HYPENINAE respectively; but the constitution of group B I is a little odd when the systematic position of the adults is considered.

Group A 1.

Mature larvae.—The four ventral pairs of prolegs nearly equal, usually with more than three setae on external face; if only three setae are present (which appears to be the case in rather poor material of *Acronicta rubiginosa*) pubescent gibbosities are present on certain abdominal terga. Secondary setae sometimes present on head or body. Verrucae may be present or absent. III on A 8 is vertically above the spiracle. IV on abdominal segments is posterior to the spiracle but may not be distinct on A 7. Crochets in a homoideous, uniordinal mesoseries. Frons higher than wide and shorter than coronal suture. Spinneret short and transverse in *Cetola*, hardly projecting beyond labial palp, the basal segment of which is small and transverse; in *Acronicta*, *Diphthera* and *Simyra* moderately slender, projecting beyond basal segment of labial palp, which is elongate, by about the length of the latter; in *Thiacidas* the basal segment of the labial palp is longer than wide and the moderately narrow spinneret projects not far beyond it. Spiracles oval, that of A 8 less than twice as large as that of A 7. Pupae in silk cocoons, between leaves (not known for *Cetola*).

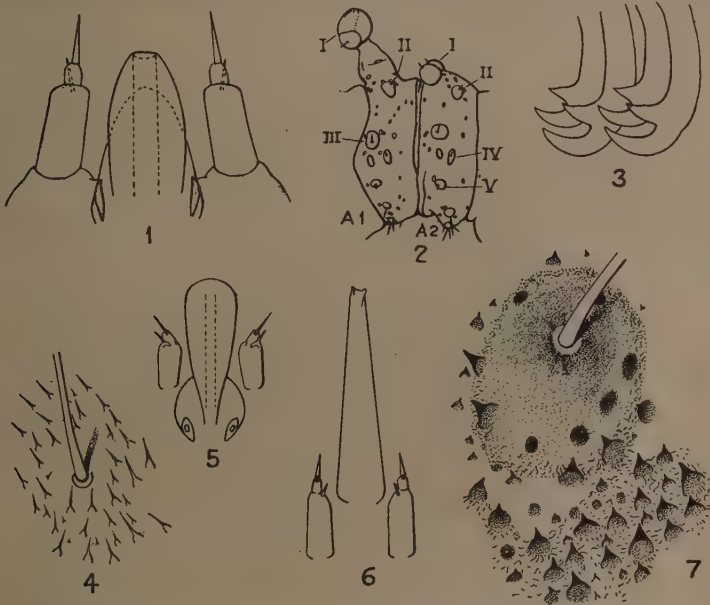
Genera included here are *Acronicta*, *Thiacidas*, *Simyra* (ACRONICTINAE), *Diphthera* (represented by *D. champa* = *Moma champa*, the adult of which appears to belong to MOMINAE) and *Cetola* (AMPHIPYRINAE). The larvae have a distinctly hairy appearance with the exception of *Cetola*, in which the hairs are sparse and very short on the upper surface; this genus is included because six setae are present externally on the ventral prolegs, instead of three as in other groups.

Key to species.

1. Head with numerous secondaries. Mesothorax with a pair of large pubescent gibbosities above *Diphthera champa*.
 Head without secondaries. Mesothorax at most with slight swellings . . . (2).
2. First abdominal tergum with a large median stalked spherical body. Setae on upper surface extremely short. (Ventral prolegs with 6 external setae) *Cetola dentata*.
 A 1 with no such appendage. Body setae long. (3).
3. Ventral prolegs with few (probably 3) external setae. Verrucae absent. (Paramedian pubescent gibbosities on A 1 to A 3 and on A 8)
 *Acronicta rubiginosa*.
 Ventral prolegs with numerous setae. At least VI is a verruca (4).
4. All primary groups above the level of VI consist of single setae. Body with a rather dense covering of short secondaries. (A 1 with median pubescent gibbosity) *Acronicta pruinosa*.
 At least I, II, III and V are verrucae with numerous setae. Secondaries, if present on body, rather long and limited to dorsum. (5).
5. Verruca IV on abdomen with numerous setae, subequal to verruca III. Skin mostly smooth. (Secondaries present above on abdomen)
 *Thiacidas postica*.
 Verruca IV much smaller than III, with not more than about 6 setae. Skin closely covered with small points (6).
6. Labrum with very shallow emargination. Verruca IV on abdomen usually with 6 setae *Simyra conspersa*.
 Labrum with stronger emargination. Verruca IV vestigial, usually with 2 to 4 setae *Acronicta bicolor*.

Cetola dentata Walker.

Head without secondaries. Frons a little higher than wide, shorter than coronal suture. Adfrons rather wide, specially on upper half. Labral emargination small, abrupt, nearly one-third deep. Mandible with three distinct teeth and a small dorsal angulation distally; with a rather large obtuse internal tooth. Spinneret very short, hardly longer than wide, truncate distally. Basal segment of labial palp not longer than wide. Body setae borne singly on very distinct convex tubercles, those of setae I on A 2 and A 3 being more prominent; mediodorsally on A 1 and bearing setae I is a spherical body with a fairly long stalk (fig. 2); the body setae normally arranged but there are six external setae on



FIGS. 1-7.—1. *Thiacidia postica*, spinneret and labial palps; 2. *Cetola dentata*, 1st and 2nd abdominal segments, lateral view; 3. *Adisura atkinsoni*, crochets; 4. *A. atkinsoni*, skin; 5. *A. atkinsoni*, spinneret and palps; 6. *Pyrrhia umbra*, spinneret and palps; 7. *P. umbra*, skin.

each ventral proleg; the setae above that level extremely short. Spiracles black, large, of A 7 about three-fourths that of A 8. Body skin closely covered (except for scattered smooth spots) with fairly coarse granules; setiferous tubercles extremely finely granulate. Length about 35 mm. Head dark brown; body with brown variegation; A 8 white, this extending forward on to dorsum of A 7. Setiferous tubercles dark brown, but some pale. Legs black; prolegs with dark brown external plate. (Material in alcohol.) Two larvae on *Cordia myxa*, Coorg. Adults were reared but the mode of pupation was not noted.

This larva is at once distinguished by the peculiar stalked sphere on A 1. The presence of six setae on the prolegs makes inclusion with the *ACRONICTINAE* convenient although this may not be its natural position.

Simyra conspersa Moore.

Frons small; adfrons wide especially above frons. Labral emargination very shallow. Mandible with two very small teeth near middle of distal edge; with a bidentate internal

tooth. Spinneret distinctly longer than basal segment of labial palp (which is elongate) and extending about to the apex of the distal seta of the palp; moderately slender, slightly narrowed apically. Body setae fine, rather long, in groups on moderately raised and normally arranged verrucae; IV (behind spiracle) small, with up to six setae. Spiracles pale with black rims; large, that of A 7 nearly as large as that of A 8. Secondaries absent except on prolegs where they are numerous. Skin with close sharply pointed granules, in part with microtrichia. Length about 30 mm.

Head testaceous with blackish mottling. Body pale with black mottling above. Legs testaceous; prolegs brownish externally. Setae mostly pale, a few above black. Described from two larvae in alcohol kindly provided by Dr. T. V. Ramakrishna Ayyar, who found them feeding on *Lotus* in Hyderabad, Deccan.

Thiacidas postica Walker.

I described this larva (1941, *Indian Forest Rec.* 6 (9) : 299) as a Lymantriid, pointing out that the larva was unusual in not having dorsal glands on A 6, A 7. It has been shown by Collenette (1935, *Stylops* : 242) that *Thiacidas* belongs to the ACRONYCTINAE and not to the LYMANTRIIDAE and the larval structure confirms this. The mandible with three rather blunt distal teeth, a small post-apical tooth on dorsal margin and a fairly large triangular internal tooth. Spinneret as in fig. 1.

Acronicta pruinosa Guen. and *A. rubiginosa* Walker.

These species have been previously described (Gardner 1941, *Indian Forest Rec.* 6 (8) : 265). In *rubiginosa* the distal margin of the mandible is entire except for a tooth at the lower extremity and there is a triangular internal tooth. The spinneret gradually tapers to a truncate apex and extends to the apex of the distal seta of labial palp (which has an elongate basal segment).

Acronicta bicolor Moore.

Labral emargination widely curved, about one-third deep. Secondary setae confined to well-developed verrucae (but IV with only two to four setae) except on pronotum and prolegs where they are numerous. Dorsal verrucae with finely plumose white setae (brown on A 1) as well as stiff needles. Verrucae I and II approximate on A 1 to A 7. Lateral setae finely plumed. Head black; body mottled with red and black; verrucae white except those on A 8 to A 10, which are brownish; an irregular white subspiracular line. Length about 45 mm. Larva on unknown weed; Garhwal (*Balwant Singh*).

Acronicta indica Moore.

This was described (1941, *J. Bombay nat. Hist. Soc.* 42 : 755) by Mr. Sevastopulo, who has kindly lent me an inflated specimen. This is very close to *A. bicolor*, but is on the whole darker, the dorsal verrucae darker; the dorsal setae on A 1 black. In both species the spiracles are white and legs and prolegs blackish. Feeds on *Plantago* sp.; Shillong.

Diphthera champa Moore.

This was also described in the same paper. The distal edge of mandible with two weak teeth near the middle and with a transverse internal ridge-like tooth. The spinneret extending about as far as distal seta of labial palp, which has the basal segment much longer than wide. The larva first described was

from *Prunus communis*, Simla; I have since reared the species on *Pyrus pashia*, Dehra Dun. The generic name *Diphthera* was given to the associated moth by Miss Prout; the species is referred to in literature under *Moma*.

Group A IV.

Body form normal with no marked swellings or protuberances other than setiferous pimples. Adfrons distant from vertical sinus. Frons subequal to or slightly longer than coronal suture. Labrum with shallow obtuse emargination. Spinneret extending far or only slightly beyond labial palps. Setae normal; III on A 8 vertically above the spiracle; group VII bisetose on A 7, trisetose on A 2. Ventral prolegs nearly equal. Crochets biordinal, homoideous. Body skin closely covered with granules with fine points which tend to become hair-like on the ventral surfaces. Larvae pupate in the soil in cocoons of earth and silk.

Genera included here are *Heliothis*, *Adisura* (in Warren's MELICLEPTINAE) and *Pyrria* (AMPHIPYRINAE). Although seemingly widely separated by certain characters of the adult, *Pyrria* and *Heliothis* are extremely close as larvae.

Heliothis armigera Hübner.

The larva, which was described previously (Gardner 1941), is extremely variable in colour. The spinneret is tapering, slender and extends far beyond the labial palps. Certain of the body setae on small shining pimples. Frons not longer than coronal suture. Granules on body closer and less hair-like (except on prolegs) than in *Adisura*. Crochets simple. Mandibles with distal teeth and no distinct internal tooth. Spiracles rather large, oval.

Pyrria umbra Hufnagel.

This closely resembles *H. armigera*. The granules on the skin are rather coarser (fig. 7). Each mandible with a strong internal tooth (in two preserved larvae but not distinct or worn down in exuviae). Spinneret (fig. 6) long and tapering. There are two distinct forms of larvae: one pale green with the setae on small pimples, which are pale except III and IV, which are black and smaller than the spiracles; the other form with black, white and red (this subspiracular) stripes and with the setae on black pimples which are larger than the spiracles. Larvae were found defoliating *Rhododendron arboreum* in Mussoorie, May, 1944; pupal period 25 days.

Adisura atkinsoni Moore.

At once distinguished from the above two species by the crochets which, except for those at the extremities of the mesoseries, are appendiculate (fig. 3). Body setae not raised basally. Frons longer than coronal suture. Spinneret (fig. 5) extending only slightly beyond palps, rather wide, obtuse at apex. Body less closely covered with granules (fig. 4), which are finer. Spiracles smaller, broadly oval. Colour variable; head testaceous; body pale green with or without a dark red band along the body and including the spiracles, which may be disrupted by white speckling; legs and prolegs pale testaceous; spiracles pale reddish. Larvae were taken (with those of *H. armigera*) feeding in fruits of *Hibiscus mutabilis*, Dehra Dun.

Group B I.

Mature larvae.—Prolegs well developed on A 5, A 6 and A 10; the crochets (except sometimes at the extremities of the mesoseries) each with a large additional postapical tooth (fig. 8); uniordinal. Prolegs of A 3, A 4 very small to minute, or absent or repre-

sented by a minute point; the crochets, when present, simple and with a tendency to arrangement in a penellipse.

Frons small, the two setae above the level of the pores. Ocelli 1 to 4 nearly equally spaced. Mandible usually with distinct internal tooth. Spinneret usually slender, tapering, extending beyond labial palps. Seta III of A 8 varies from well (but not quite vertically) above, to anterior to the dorsal extremity of the spiracle. Body setae rather long, usually on small basal papillae, normally arranged; secondaries absent. Spiracle of A 8 much larger than that of A 7. Larvae slender, without abrupt swellings. Pupation in ovoid cocoon in the soil.



FIGS. 8-14.—8. Crochet of: (a) *Acontia intersepta*, (b) *Amyna leucostriga*, (c) *Elydna transversa*, (d) *Androlymnia emarginata*, (e) *Chasmina tibialis*, (f) *Bocula hypenoides*; 9. *Chasmina judicata*, spinneret and palps; 10. G. 5664, labrum; 11. G. 5664, half of a mesoseries of crochets; 12. *Amyna leucostriga*, labrum; 13. *Bocula hypenoides*, labrum; 14. *Androlymnia emarginata*, labrum.

The genera included here have been grouped on adult characters in four different subfamilies: ACONTIINAE (*Acontia*), AMPHIPYRINAE (*Elydna*, *Chasmina*, *Androlymnia*), ERASTRINIÆ (*Amyna*) and NOCTUINAE (*Bocula*). *Xanthograptia* (ERASTRINIÆ) also has very small prolegs on A 3, A 4 but the crochets on A 5, A 6 are simple and the species is therefore excluded. I have included one species the adult of which has not so far been determined.

This group, although apparently highly artificial if adult classification is considered, seems to form a sharply defined group of larvae. It must be pointed out that the larva of *Elydna transversa* Wlk. has nothing to do with that of *Elydna reclusa* Wlk., which has the larval characters of the AMPHIPYRINAE. If both species are correctly identified they cannot be congeneric. I

am indebted to the Entomologist, Tea Research Institute, Ceylon, for larvae of the latter species which must be discussed under another group. Larvae of certain other genera included by Hampson (*Cat. Phalaenae* 1912) in ACONTIINAE are not closely related to *Acontia* although related to one another: such are *Pseudelydna*, *Carea*, *Maurilia*, *Aitieta*.

Key to species.

1. Crochets (fig. 11) strongly heteroideous. Labral emargination (fig. 10) two-thirds deep and very acute. G. 5664.
Without those characters (2).
2. Seta III on A 8 well above spiracle and only slightly more cephalad
Seta III on A 8 at most slightly above level of spiracle and distinctly more cephalad *Acontia* spp. (3).
3. Postapical tooth of crochets blunt. (Prolegs of A 3, A 4 minute, reduced to a point or with only 2 or 3 crochets) (4).
Postapical tooth of crochets acute (5).
4. Labral emargination a wide shallow curve. (Head with a conspicuous black spot on each side dorsally) *Androlymnia emarginata*.
Labral emargination more abruptly incurved. (Head setae on small black dots) *Amyna* spp.
5. Prolegs and crochets absent from A 3 and A 4 *Chasmina judicata*.
Prolegs small but distinct on A 3, A 4; crochets present (6).
6. Labral emargination acute. Head at most obscurely granulate (7).
Labral emargination not acute, approximately right angled. Head distinctly granulate *Chasmina tibialis*.
7. Spiracle of A 8 more than twice as large as that of A 7 *Bocula hypenoides*.
Spiracle of A 8 about 1.5 times as large as that of A 7. (Labral emargination more than one-third deep) *Elydna transversa*.

Acontia spp.

Larvae of *malvae* Esper, *transversa* Guen., and *intersepta* Guen. were previously described (Gardner 1941 : 279). Frons distinctly higher than wide. Seta III on A 8 well above spiracle and only slightly anterior to its vertical axis. Postapical tooth of crochets on A 5, A 6 (fig. 8, a) acute. Prolegs of A 3, A 4 reduced to five or six minute crochets.

Amyna spp.

Larvae of *octo* Guen. and *natalis* Walker were previously described (Gardner 1941 : 273). Postapical tooth of crochets (fig. 8, b) blunt, nearly right-angled. Prolegs of A 3, A 4 represented each by a minute point. Spiracle A 8 twice as large as that of A 7. Seta III on A 8 anterior to upper margin of spiracle. Larvae of *A. leucostigma* Hamps., feeding on a weed in Garhwal, are similar; labrum as in fig. 12.

Chasmina tibialis Fabricius.

Head distinctly granulate, frons more than half as long as coronal suture. Seta III on A 8 anterior to and slightly above level of spiracle. Postapical tooth of crochets (fig. 8, e) slender, acute. Prolegs of A 3, A 4 small with numerous crochets. Spiracle of A 7 more than half as large as that of A 8. Head infuscated; body green with two small black spots above on T 2, T 3; legs, prolegs and spiracles pale. Length about 40 mm. Larvae feeding on *Grewia disperma*, Dehra Dun. In earlier instars the leg and most of the setiferous pimples are mostly black. In one larva the postapical teeth of the crochets are vestigial.

Chasmina judicata Walker.

Head not granulate, frons about half as long as coronal suture. Seta III on A 8 anterior to and above level of spiracle. Postapical tooth of crochets acute and nearly as long as apical tooth. Spiracle A 8 about twice as large as that of A 7. Prolegs of A 3, A 4 absent. Body green with black setiferous papillae; head with numerous small black dots. Length about 25 mm. Larvae on *Helicteres isora*, Dehra Dun. Spinneret as in fig. 9.

Bocula hypenoides Moore.

Head not granulate; frons small, about as high as wide. Seta III on A 8 anterior to upper extremity of spiracle. Labral emargination as in fig. 13. Postapical tooth of crochets (fig. 8, f) acute, shorter than apical tooth. Prolegs of A 3, A 4 small, protuberant, with curved series of small crochets. Spiracle of A 8 about 2.5 times as large as that of A 7. Head and body pale green, the former with a reddish line on each side, the latter with mediodorsal reddish spots on each segment; setae brown, on brown papillae. Spiracles brown. Length about 44 mm.—Larvae on *Grewia tiliaefolia*, Dehra Dun.

Elydna transversa Walker.

Head with very obscure granulation; frons higher than wide. Postapical tooth of crochets acute (fig. 8, c). Prolegs of A 3, A 4 very small but distinct, with curved series of crochets. Spiracle of A 8 less than twice as large as that of A 7. Seta III anterior to upper extremity of spiracle on A 8. Labral emargination acute. Head pale green, rusty brown posteriorly; body pale green with rusty dorsal patches on thoracic segments and a variable rusty line dorsolaterally on each side of abdomen; setae III on black papillae which are rather larger than the others; spiracles dull ochreous. Length about 45 mm.—Larvae on *Schleichera trijuga*, Dehra Dun.

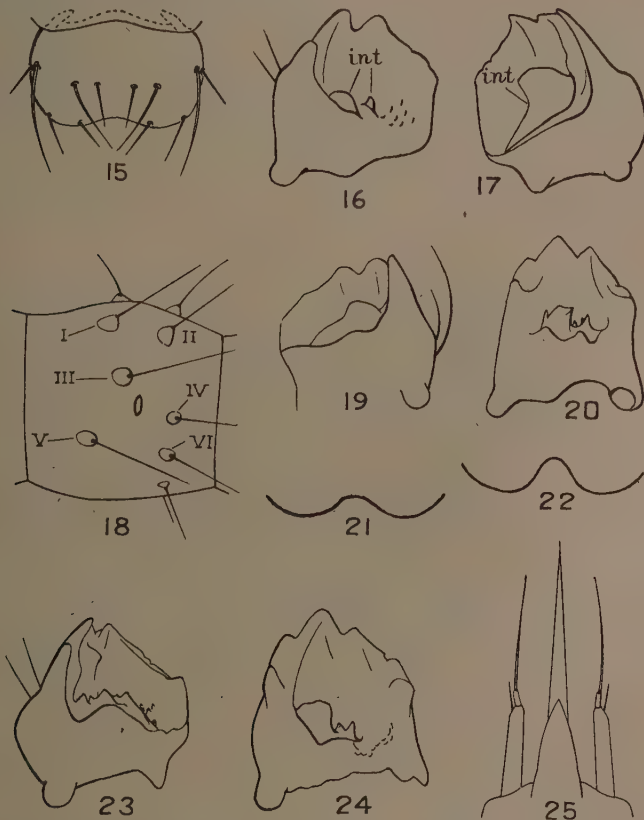
Androlymnia emarginata Hampson.

Labral emargination (fig. 14) very shallow. Spiracle of A 8 more than twice as large as that of A 7. Seta III on A 8 anterior to spiracle and slightly higher. Postapical teeth of crochets rather blunt. Prolegs on A 3, A 4 minute, represented by two or three crochets (absent in earlier instars). Mandible with obtuse internal tooth. Head yellow with a small circular black spot (absent in early instars) on each side of vertex. Body pale green with irregular white and yellow line at spiracular level; a whitish bloom on dorsal surface. Head setae not on black dots; body setae on small white pimples. Legs and prolegs pale. Length about 28 mm. Feeds on *Grewia laevigata* in Dehra Dun (August, September).

G. 5664.—Frons not higher than wide, less than half total length of coronal suture. Labral emargination (fig. 10) two-thirds deep, very acute. Mandibles with distal margin entire; with a transverse internal ridge. Spinneret nearly parallel-sided, extending well beyond basal segment of palp, slightly bilobed at the apex, which is not markedly narrowed. Setal rings of body scarcely raised above the body surface. Setae rather short, III on A 8 above and distinctly more cephalad than the spiracle. Spiracles finely rimmed with dark brown, of A 7 about two-thirds that of A 8. Prolegs absent from A 3, A 4. Crochets of other prolegs (fig. 11) of two forms: those in the middle each with a sharp postapical tooth behind the apex, those on the anterior and posterior quarters or so of each mesoseries straight, vestigial. Length of body about 25 mm. Pale green, body with two faint and fine yellow lines along each side. Setae of head on small black spots; of body on very fine black dots (setal rings) except dorsally.—Larvae defoliate *Derris scandens*, Dehra Dun. Moths were sent to the British Museum (N.H.), but have not yet been identified.

Group B II.

Mature larvae.—Prolegs on A 4, A 5 and A 6 equal in length, those on A 4 at most only slightly more slender. Prolegs either absent from A 3 or minute and with a curved row of small crochets on that segment. Body setae on raised pimples which may be small (but distinct) to quite large. Seta III on A 8 (fig. 18) well above the spiracle but slightly more cephalad, that is, not quite vertically above it.



FIGS. 15-25.—15. *Hypena ignotalis*, labrum; 16. *H. iconicalis*, mandible; 17. *H. proboscidalis* var., mandible; 18. *Rhynchina abducalis*, lateral view of A 8; 19. *Hypena uniformis*, mandible; 20. *Rhynchina abducalis*, mandible; 21. *Dichromia orosia*, labral emargination; 22. *D. trigonalis*, labral emargination; 23. *Hypena rectivittalis*, mandible; 24. *H. sublividalis*, mandible; 25. *H. iconicalis*, spinneret and palps. *int* = internal tooth.

Frons higher than wide and shorter than coronal suture; the two frontal setae above the level of the frontal pores and near frontal sutures on each side. Labral emargination evenly curved, from very shallow (in *Hypena ignotalis*) to about one-third deep. Mandible with three distal teeth and usually with distinct internal teeth. Labial palp with elongate basal segment and a small second segment bearing a long apical seta which extends to about the apex of the spinneret. Spinneret (fig. 25) tapering, slender, finely attenuate distally; the basal shield which covers nearly the basal half of the anterior surface of the spinneret usually

acute distally but rounded in *Bomolocha triangularis*. Body setae rather long, normally arranged; group VII with three setae on both A 1 and A 2. Crochets normal, uniordinal; in a specimen of *H. ignotalis* the number of crochets on A 4, A 5 and A 6 is 15, 17, 19 respectively. Spiracles elliptical, those of A 1 to A 7 from three-fourths to one-half as large as those of A 8. The body skin closely covered with skin points usually seen only under high magnification. Body slender, up to about 25 mm. in length.

Larvae included in group B II belong to the genera *Hypena*, *Dichromia*, *Rhynchina* and *Bomolocha*, all HYPENINAE. The larva of *H. auroincta* Hampson differs, however, in certain ways and is discussed under another group.

The food-plants concerned are Urticaceae (*Boehmeria*, *Girardinia*), Leguminosae (*Butea*, *Desmodium*, *Indigofera*, *Ougeinia*), Verbenaceae (*Lantana*) and Asclepiadaceae (*Tylophora*). *Hypena conscitalis* eats the flowers and fruits of *Desmodium gangeticum*; the other species are leaf feeders. Cocoons are made between leaves or of particles of soil and debris held together with thin silk.

Key to species.

1. Very small prolegs, with crochets, present on A 3 (2).
A 3 without prolegs. (4).
2. Setiferous pimples of body large, black and set in black spots. (Mandible (fig. 16) with two internal teeth, one larger obtuse, the other more acute)
Hypena iconicalis.
Setiferous pimples small, only the setal rings black. (3).
3. Mandible (fig. 23) with numerous small irregular internal teeth. Some of head setae on black spots *H. rectivittalis*.
Mandible (fig. 19) with one obtuse internal tooth. Setal rings of head black
H. uniformis.
Mandible (fig. 20) with two larger pointed internal teeth and 2 or 3 small ones.
Head setae not on black spots *Rhynchina abducalis*.
4. Body setae on strong black pimples. (Spiracles black, those of A 1 to A 7 smaller than usual. Internal tooth of mandible obtuse, rather weak). . . (5).
Body setae on finer pimples, only the tips of which may be black . . . (6).
5. Labral emargination (fig. 21) shallow, widely curved. Setiferous pimples larger, those bearing setae I on any abdominal segment narrowly separated
Dichromia orosia.
Labral emargination (fig. 22) more abrupt. Setiferous pimples smaller, those bearing I separated by more than the diameter of one of them
Dichromia trigonalis.
6. Labral emargination (fig. 15) extremely shallow. Mandible with no internal tooth *Hypena ignotalis*.
Labral emargination more deeply curved. Mandibles with internal teeth . (7).
7. Mandible with numerous small internal teeth *H. conscitalis*.
Mandible (fig. 24) with one large obtuse and two small acute internal teeth
H. sublividalis.
Mandible with one blunt tooth (8).
8. Internal tooth (fig. 17) large. Labral emargination rather shallow
H. proboscidalis ab. *indicalis*.
Internal tooth small. Labral emargination more abruptly curved . . . (9).
9. Head with black speckling. Spiracles with black rims *Bomolocha triangularis*.
Head not speckled with black. Spiracles pale *Bomolocha occata*.

Bomolocha occata Moore.

On *Boehmeria platyphylla*; Dehra Dun. Labral emargination rather abruptly curved. Larva pale green; spiracles pale; setiferous pimples tipped with black.

Bomolocha triangularis Moore.

On *Boehmeria platyphylla*; Dehra Dun. Pale green, head with some black speckling; spiracles and tips of setiferous pimples black; two irregular white lines along each side of body.

Hypena iconicalis Walker.

On *Desmodium gangeticum* and *Butea frondosa*; Dehra Dun. Labral emargination about one-third deep. Head testaceous with large black setal spots. Body smoky blackish with a dorsal white spot on A 1 to A 3 and on A 8; a yellow spiracular line on each side. Legs mostly black; ventral prolegs with fuscous plate. Spiracles pale red. Setiferous pimples large and conspicuous, black and on black spots. Spinneret as in fig. 25.

Hypena rectivittalis Moore.

On *Desmodium gangeticum*; Dehra Dun. Labral emargination a wide curve. Head pale yellowish; body pale green with a whitish line along each side. Legs pale reddish. Prolegs and spiracles pale.

Hypena conscitilis Walker.

On flowers and fruits of *Desmodium gangeticum*; Dehra Dun. Labral emargination a wide curve. Head and body pale green, the head with a vague reddish line on each side; body segments rusty brown posteriorly. Legs and prolegs pale. Spiracles with pale reddish margins.

Hypena ignotalis Walker.

On *Lantana camara*; Dehra Dun. Labral emargination (fig. 15) extremely shallow. Pale green; spiracles with fine dark rims; only the setiferous rings on head and body black. This is the only species in which the mandible has no internal tooth.

Hypena proboscidalis ab. *indicalis* Guenee.

On *Girardinia heterophylla*; Garhwal. Labral emargination rather shallow. Head pale green, speckled with black posteriorly; setal rings black. Body partly green, partly fuscous; setae on black-tipped pimples set in green spots. Legs and prolegs pale green. Spiracles with fine black rims.

Hypena uniformis Hampson.

On *Indigofera pulchella*; Dehra Dun. Labral emargination rather deeply curved, one-third deep. Pale green, the setal rings of head and body black. Spiracles with fine black margins. (Identification of moth from Hampson's description; requires confirmation.)

Hypena sublividalis Snellen.

On *Desmodium gangeticum*; Dehra Dun. Labral emargination abruptly curved. Pale green with vague darker stripes dorsally; setal rings of head and body black. Legs and prolegs pale. Spiracles with pale reddish rims.

Dichromia trigonalis Guenee.

On *Boehmeria platyphylla*; Dehra Dun. Labral emargination about one-third deep; rather abruptly curved. Head pale brown with rather large black spots. Body brownish with some fuscous shading. Legs with some black; prolegs with black setiferous spots; spiracles black. The black setiferous pimples, set in blackish spots, are very conspicuous.

Dichromia orosia Cramer.

On *Tylophora hirsuta*; Dehra Dun. Labral emargination shallowly curved. Head, thorax and posterior extremity yellow; in the middle segments the yellow reduced to intersegmental rings dorsally; remainder blackish-green. Legs black; prolegs yellow with black external plate. Spiracles black. Setiferous pimples and spots on head black.

Rhynchina abducalis Walker.

On *Ougeinia dalbergioides*; Dehra Dun. Labral emargination rather deeply curved. Head pale yellowish. Body green with two faint white lines along each side, only the setal rings black. Legs, prolegs and spiracles pale.

EXD. 8
MAY 1946
Vol. 96. Part 5 Pp. 73-88, 7 pls.

30th April, 1946.

E4.344.

THE
TRANSACTIONS
OF THE
ROYAL
ENTOMOLOGICAL SOCIETY
OF
LONDON

World List abbreviation: Trans. R. ent. Soc. Lond.

CONTENTS

PAGE

- ✦ CORBET, A. Steven, D.Sc., Ph.D., F.R.I.C., F.R.E.S.
Observations on the Indo-Malayan species of the genus
Arhopala Boisduval (Lepidoptera: LYCAENIDAE) . 73-88, 7 pls.

LONDON:

PUBLISHED BY THE SOCIETY AND
SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 10s. 0d.

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Founded, 1833. Incorporated by Royal Charter, 1885.

PATRON—HIS MAJESTY THE KING.

OFFICERS and COUNCIL for the SESSION, 1946-1947.

PROF. G. D. HALE CARPENTER, M.B.E., D.M., *President*.

W. J. HALL, D.Sc.

C. B. WILLIAMS, M.A., D.Sc. } *Vice-Presidents*.

H. B. WILLIAMS, LL.D. }

A. WELTI, *Treasurer*.

N. D. RILEY, *Secretary*.

Other Members of Council.

C. H. ANDREWES, F.R.S.

J. W. EVANS, M.A., D.Sc.

G. FOX-WILSON, N.D.H.

R. M. GREENSLADE.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

CAPT. R. A. JACKSON, R.N.

MISS C. E. LONGFIELD.

SIR GUY A. K. MARSHALL, K.C.M.G.,
D.Sc., F.R.S.

G. E. J. NIXON, B.A.

J. F. PERKINS, B.Sc.

F. J. GRIFFIN, A.L.A., *Registrar*.

Finance and House Committee.

G. FOX-WILSON, N.D.H. (*Chairman*).

J. W. EVANS, M.A., D.Sc.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

W. RAIT-SMITH.

O. W. RICHARDS, M.A., D.Sc.

Publication and Library Committee.

W. J. HALL, D.Sc. (*Chairman*).

H. E. HINTON, B.Sc., Ph.D.

B. M. HOBBY, M.A., D.Phil.

J. F. PERKINS, B.Sc.

J. SMART, B.Sc., Ph.D.

W. H. THORPE, M.A., Sc.D.

Committee on Generic Nomenclature.

FRANCIS HEMMING, C.M.G., C.B.E. (*Chairman*).

W. A. F. BALFOUR-BROWNE, F.R.S.E.

K. G. BLAIR, D.Sc.

O. W. RICHARDS, M.A., D.Sc.

N. D. RILEY (*Secretary*).

Committee for the Protection of British Insects.

H. M. EDELSTEN, O.B.E. (*Chairman*).

R. B. BENSON, M.A.

E. A. COCKAYNE, M.A., M.D., F.R.C.P.

CAPT. R. A. JACKSON, R.N.

COL. F. A. LABOUCHERE.

A. M. MASSEE, D.Sc.

THE HON. MIRIAM ROTHCHILD.

W. H. THORPE, M.A., Sc.D.

N. D. RILEY (*Secretary*).

The Executive Officers of the Society are *ex-officio* members of all Committees.

DELEGATES OF THE SOCIETY TO:

1. British National Committee for Biology (Royal Society).

Sir Guy A. K. Marshall, K.C.M.G., D.Sc., F.R.S., appointed 1939.

Dr. V. B. Wigglesworth, M.A., B.Ch., M.D., F.R.S., appointed 1943.

2. Local Committee of Management of Wicken Fen.

Mr. H. M. Edelsten, O.B.E. [nominated by Committee for the Protection of British Insects].

3. National Trust for Places of Historic Interest or Natural Beauty.

Mr. H. M. Edelsten, O.B.E., appointed 1944.

4. New Forest Association.

Mr. W. Fassnidge, appointed 1934.

5. New Forest Joint Committee.

Mr. W. Fassnidge, appointed 1939. Dr. F. J. Killington, D.Sc., A.L.S., appointed 1939.

6. Royal Meteorological Society. Phenological Committee.

Dr. C. B. Williams, M.A., D.Sc., appointed 1937.

7. Biology War Committee.

Prof. P. A. Buxton, M.A., F.R.S., appointed 1941.

8. Council for the Promotion of Field Studies.

Dr. W. H. Thorpe, M.A., Sc.D., appointed 1944.

9. Joint Bioclimatic Committee.

Dr. B. P. Uvarov, C.M.G., D.Sc., appointed 1945.

Dr. C. B. Williams, M.A., D.Sc., appointed 1945.

OBSERVATIONS ON THE INDO-MALAYAN SPECIES OF THE GENUS
ARHOPALA BOISDUVAL (LEPIDOPTERA: LYCAENIDAE)

By A. Steven CORBET, D.Sc., Ph.D., F.R.I.C., F.R.E.S.

(British Museum, Natural History.)

Manuscript received 27 February, 1945.

(Read 7th November, 1945.)

WITH 7 PLATES.

THE remarkable multiplicity of closely allied species in certain invertebrate groups inhabiting Malaysia to-day is doubtless to be attributed to the repeated union and separation of the Large Sunda Islands (Sumatra, Borneo and Java) and Malaya which took place during the Pleistocene. The phenomenon is one of considerable biological interest and deserves greater attention than it has received hitherto. One of the difficulties of study lies in the fact that the correct determination of species with numerous similar congeners can only follow extensive research. In the Malay regions, at least, the present position is that the insect groups which could throw most light on the subject of species-formation are, in fact, usually those about which least is known.

The two outstanding features of the Sunda Shelf, on which the Large Sunda Islands and the Malay Peninsula rest, are its shallowness (depths exceeding 30 fathoms are extremely rare), and the remarkable uniformity of the surface (Molengraaff, 1921).

During the climatic phases corresponding to the glaciations in the temperate regions of the world, much or all of the Sunda Shelf was exposed so that there was uninterrupted land passage between the neighbouring islands and the present Peninsula. These land connections disappeared with the melting of the ice-sheets, and there is evidence indicating that, at times, the sea-level was raised at least 50 feet, and possibly even 200 to 300 feet, above the present level (Zeuner, 1941: 118). It is generally recognised that prolonged isolation is a usual cause of species-formation so that, during the interglacial periods, when the insular representatives of the more widely distributed species remained isolated, conditions were favourable for the development of distinct geographical races (subspecies) and then, provided the isolation was sufficiently prolonged, for their further development into species.

It will be appreciated that, with those insect groups which were in the susceptible phase of evolution (corresponding to the "phase of increase" of the species "growth-curve," Corbet, 1933), the changing environmental conditions of the Pleistocene set the stage for the production of a number of bewildering complexes of closely allied forms of uncertain systematic status. What appears to be an excellent example of this phenomenon of specific multiplicity is exhibited in the large Lycaenid genus *Arhopala* Bsdv., of which there are 111 species¹ known from the Indo-Malayan Region and, perhaps, some 40 odd further species in the more easterly parts of the Malay Archipelago. This is, by far, the largest Oriental genus of butterflies and, as yet, all attempts to split it into sub-genera

¹ This figure is arrived at from the data given in Corbet, 1941a, except that *A. anarte* (Hew.) and *A. auzea* Nic. are regarded as conspecific, as are *A. amphimuta* (Feld.) and *A. batuensis* B.Bkr., and *A. malayana* B.Bkr. has been left out of consideration.

or other smaller units on a biological basis have failed. There is no doubt that the "oakblue" butterflies, as they have been called, present a problem to the systematist: so similar are many of the *Arhopala* species, both as regards facies and genitalia, that their specific status is likely to remain uncertain for some time to come.

Distribution of the Indo-Malayan species.

It is certain that a few species of *Arhopala* await discovery in Neomalaya (using the term as defined by Moulton, 1915, to include Malaya, Sumatra and Borneo), where the genus has given rise to most species, but it is now possible to give a picture of the distribution of the Indo-Malayan forms with a fair degree of accuracy, although there is a paucity of information regarding the position in Siam and Indo-China. According to the material in the collections of the British Museum, the 111 species of *Arhopala* known from the Indo-Malayan Region (*i.e.*, Ceylon to Malaysia) are distributed in the respective countries as follows:—

Ceylon	4 (3.6%)	Malaya	82 (73.9%)
India	36 (32.4%)	Sumatra	57 (51.4%)
Burma (north of Mergui)	63 (56.8%)	Borneo	60 (54.1%)
Siam	37 (33.3%)	Java	23 (20.7%)
Indo-China	9 (8.1%)		

Of the above species, 3 (2.7%) occur also in the Celebes, 10 (9.0%) in the Philippines (exclusive of Palawan) but only 3 (2.7%) of these have spread farther east.

It is only from the Malay Peninsula that we have much detailed information regarding the local distribution of the *Arhopala* species. Of the 82 species known from Malaya, only 8 (9.8%) have not been found below 2500 feet while 63 (76.8%) have not been found above this altitude: 11 species (13.4%) are known from both sides of the 2500-foot line. When compared with the corresponding figures for the altitudinal distribution for the whole of the Malayan Rhopalocera (15.8, 58.4 and 25.8% respectively), it is evident that the *Arhopala* species in Malaya are essentially lowland and not montane in habit. It is interesting to note that, as is usual, a considerable proportion of the montane species (in this case 4 out of 8), are not found south of Singapore and must be regarded as comparatively recent arrivals from Burma since the final separation of Malaya from Sumatra. The high proportion of species confined to the plains, of course, favoured constant intermingling of forms when the sea-level fell and the land masses became re-united during the Pleistocene glaciations.

It is evident that Neomalaya is the home of the genus, for 87 of the 111 Indo-Malayan species (*i.e.*, 78.4%) are found in this sub-region and remarkably few of these have crossed the Wallace Line (*vide* Zeuner, 1943). In Malaya proper (Corbet, 1941b), the *Arhopala* forms are practically confined to primary forest and presumably the same obtains in Sumatra and Borneo. On the other hand, in the northern part of Malaya recently named Kedawi, in Burma and, probably, in Java also, some of the species are found frequently in secondary plant associations.

The relative abundance of the Malayan species of *Arhopala*.

In Malaya, individuals of all the *Arhopala* species other than *A. centaurus* (Fab.) are rare. In Table 1 are given the results of my own collecting in Malaya

from 1927 to 1932. The Malayan species so collected are divided into frequency groups depending on the number of individual specimens of each species collected. The species are divided also according to their extra-Malayan distribution, the "northern" species being those not found south of Singapore and the "southern" species those not known from north of Mergui, as defined in a previous paper (Corbet, 1941b). The coefficient of abundance is a measure of the relative abundance of a species or group of species and is calculated from the numbers of species in the frequency groups by the formula employed previously. The greater the coefficient of abundance the more abundant the species or groups of species. For purposes of comparison, there is given also in Table 1 the coefficient of abundance for the Malayan *Rhopalocera* as a whole, based on my own collecting from 1927 to 1932.

As was found with the Malayan butterflies as a whole, with the *Arhopala* species, the "northern" species are the rarest, the "southern" species next, while the more widely distributed species are the least rare.

TABLE 1.

The relative abundance of Malayan *Arhopala* species arranged according to distribution groups.

Malayan species of <i>Arhopala</i>							Whole of Malayan <i>Rhopalocera</i>	
Distribution group	Species	Number of species in each frequency group					Species	Coefficient of abundance
		(a)	(b)	(c)	(d)	(e)		
Northern . . .	8	—	—	1	2	5	99	1.96
Southern . . .	35	—	3	2	10	20	243	2.28
Burma to Java . .	19	—	1	2	9	7	260	2.77
Ceylon to Java . .	1	—	1	—	—	—	120	3.58
Other distributions	19	—	2	1	8	8	202	1.86
Total . . .	82	—	7	6	29	40	924	2.46

In the distribution groups, the "northern" species are those not found south of Singapore, while the "southern" species are those not known north of Mergui. In the frequency groups, the species in (a) are those of which more than 24 individuals were collected by me, of those in (b) between 10 and 24 specimens were collected, (c) contains those of which between 5 and 9 were collected, (d) those of which between 1 and 4 were collected and (e) those of which I took no specimens. The coefficient of abundance is a measure of the relative abundance and was calculated according to the formula:

$$\text{coefficient of abundance} = \frac{5(a) + 4(b) + 3(c) + 2(d) + (e)}{n},$$

where n is the total number of species in the distribution group under consideration.

The Fisher Series and the number of species of *Arhopala*.

Following the examination of the numerical data relating to certain collections of insects, in which the collecting was carried out at random, it was shown that a mathematical relationship exists between the number of species and number of individual in such samples (Fisher, Corbet and Williams, 1943). A study of further data regarding insect collections has shown that this mathematical relationship is very general.

The Fisher logarithmic series, which expresses the relation between the numbers of species and individuals in a random sample, is :—

$$S = n_1 \left(1 + \frac{x}{2} + \frac{x^2}{3} + \frac{x^3}{4} + \frac{x^4}{5} + \dots \right) = n_1 \frac{-\log_e (1-x)}{x},$$

where S is the total number of species represented in the sample, n_1 is the number of species represented in the collection by a single individual and x is a number less than unity.

The total number of individuals (N) in the collection is given by the relation :—

$$N = \frac{n_1}{1-x}$$

The values of S and N being known, those of n_1 and x can be calculated. For any given population, the ratio

$$n_1/x (= a)$$

remains constant and is independent of the size of the sample, provided that sampling is carried out under identical conditions. The parameter a is, therefore, a characteristic of the population : it has been termed the *index of diversity* (Williams, 1944), for it gives a measure of the extent to which the division into species has occurred in the group under consideration. The greater the value of a , the greater the number of species for the same number of individuals.

In the case of the genus *Arhopala*, where the species exhibit such great similarity in wing pattern and genitalia, and where recent revisional work has resulted in the suppression of forms which were previously regarded as specific entities and the founding of a number of new species, it is of interest to apply any check which may serve to test the correctness or otherwise of the results of the systematic work. The mathematical considerations just referred to offer such a test when the requisite collecting data are available.

During my residence in Malaya, I personally collected 191 *Arhopala* specimens and, according to my recent systematic revision, these are divided among 42 species. From the formula given above, it is found that, given $N = 191$ and $S = 42$, then

$$a = 16.63 \text{ (standard error } 1.92), x = 0.9198 \text{ and } n_1 = 15.32.$$

This means that if the allocation of species among the 191 individuals of *Arhopala* collected by me follows the Fisher series (as would be anticipated if the arrangement was based on principles known to be of general validity in other groups of insects), it would be expected that the collection would contain about 15 species represented by single individuals. Actually, the collection contained exactly 15 species with one specimen each and, from this close agreement between the calculated and actual values, it may be assumed that my division of the *Arhopala* forms into species is in conformity with the generally accepted views regarding the limits of a species. Had the value of n_1 found been significantly different from the theoretical value determined as above, it would have suggested that the allocation of individuals among species was faulty and that the matter required re-examination.

In the particular case just illustrated, the number of individuals (191) was rather small and the standard error is correspondingly high. Had a larger collection been made, the position could have been tested with more precision. Nevertheless, it appears to me that this method offers a useful means for checking the number of species present in large genera containing numerous forms of

doubtful status. The pre-requisite is a reasonably large collection containing specimens collected at random in the same zoo-geographical unit. In actual practice, when *S* and *N* are known, the value of *a*, and hence of *n*, can easily be found from the table given by Fisher (*vide* Fisher, Corbet and Williams, 1943).

Geographical variation.

The geographical variation of the Indo-Malayan species of the genus has been discussed in Corbet, 1941a : 149.

The Male Genitalia in *Arhopala*.

The male genitalia show a remarkable uniformity throughout the genus and it is the exception rather than the rule for these organs to serve as a ready aid to identification : in comparatively few species are the genitalia highly characteristic. Often the shape of the clasper is ill defined and some species exhibit a marked individual variation in this respect. With the exception of *A. democritus* (Fab.), all the Indo-Malayan species of the *democritus* have the aedeagus strongly angled at the distal end and the species of the *apidanus* group are remarkable for the pointed uncus and, excepting *A. adriana* (Nic.), for the cornutus present in the aedeagus.

With the same male genitalia, *A. atosia* (Hew.) and *A. epimuta* (Mre.) appear to be almost identical except for the presence or absence of the hind-wing tail. *A. atosia* has a wider distribution, however, occurring as far north as the Karen Hills and also in the Mentawi Islands and Palawan from where *A. epimuta* is not yet known. In general, *A. epimuta* has the underside more reddish and the markings more distinct.

A. pseudomuta (Stgr.) and *A. amphimuta* (Feld.) also have the same male genitalia pattern and differ chiefly in that the former is tailed. There are other differences, however, and their specific distinctness cannot be questioned. In spite of the distinct genitalia, there can be little doubt that *A. baluensis* B.Bkr. is the Bornean representative of *A. amphimuta*.

The species *A. muta* (Hew.), *A. moorei* B.Bkr., *A. wallacei* Cbt., *A. tropaea* Cbt., *A. avatha* Nic., *A. avathina* Cbt. and *A. zylda* Cbt. in the *epimuta* group cannot be separated on male genitalia and the first three species are not easy to differentiate on facies : nevertheless, comparison of fresh examples from the same country leaves little or no doubt regarding their specific status. Judging by some odd specimens in the British Museum, there are other species in the *muta* section awaiting description but much more material is required before the situation can be cleared up satisfactorily.

Three species in the *democritus* group with similar male genitalia are *A. atrax* (Hew.), *A. ariana* (Evans) and *A. rafflesi* Nic. There is little difficulty in separating these species in Burma but such is not the case in Neomalaya ; in fact, with the limited material available, it is not possible to classify the Bornean forms with any degree of confidence. A similar position obtains in the *silhetensis* group where the species show no constant differences in male genitalia : in Burma and Java there is no uncertainty regarding identification but determination is often a matter of guesswork in Neomalaya. Much the same can be said of the position with *A. aroa* (Hew.), *A. kounga* B.Bkr. and *A. phaenops* Feld. in the *aroa* group.

In the *centaurus* group, *A. eumolpus* (Cram.), *A. horsfieldi* (Pagen.), *A. overdijkinki* Cbt., *A. bazalus* (Hew.) and *A. singla* (Nic.) have male genitalia of a similar pattern, and the separation of the females of the two first-named species in Neomalaya is often uncertain, for the female genitalia appear to be similar.

The position is rather obscure with respect to *A. ammonides* (Doh.), and its very rare allies *A. ammon* (Hew.), *A. ariel* (Doh.) and *A. sarawaca* Moul. in the *ganesa* group. Here, again, the male genitalia are similar and, although the species appear to be distinct enough, it is possible that some surprises await the collection of further material.

Notes on certain Indo-Malayan species of *Arhopala*.

The following notes are intended to amplify and explain some of the statements made in my recent key for the Indo-Malayan species of the genus (Corbet, 1941a).

anthelus Group.

A. ijauensis B.Bakr.

The Burmese subspecies was renamed *simonea* Cbt. (1941a : 151) since *Nilasera subfasciata* Moore (1883, *Proc. zool. Soc. Lond.* 1883 : 532), the name under which it was originally described, is preoccupied by *Narathura subfasciata* Moore (1881, *Trans. ent. Soc. Lond.* 1881 : 312), which latter name is a synonym of *A. fulla andamanica* (W.M. & Nic.).

A. achelous malu subsp. n.

♂. Upperside with the fore-wing slightly bluer than in the nominotypical form and in the race *brooksiana* Cbt., from West Sumatra; the hind-wing is slightly but distinctly paler. On both wings the black margin is distinctly broader than in Malaya and Borneo.

Underside as in *brooksiana*, entirely lacking the purple shading. Fore-wing 20 mm.

SOUTH BURMA : Mergui, v.1895 (*Lakatt & Pamboo*), ex Coll. Oberthür. B.M. Rhop. Type No. 15063. Unique.

A male from Penang (ex Coll. Joicey) resembles subspecies *malu* but the upperside black bordering is narrow as in typical *achelous*.

camdeo Group.

A. myrzala lammas Cbt.

The British Museum has 3 males and 1 female from British North Borneo, Mount Kina Balu (*J. Waterstradt*) and a male from Sandakan (*Pryer*).

A. hellada ozana Fruh.

The female of "*Narathura agnis* Felder" figured in Distant, pl. xxi, fig. 29, is *A. hellada ozana* Fruh. and the specimen depicted appears to be one obtained in Malacca by Captain S. Pinwill prior to 1876. The same specimen is illustrated at pl. 2, fig. 13, in this paper.

A. camdeo (Mre.).

Amblypodia camdeo Moore, 1857, in Horsfield & Moore, *Cat. Lep. Mus. E. I. Co.* 1 : 41, pl. ia, fig. 6 ♀; ♂♀, North India.

As Moore failed to select a type among his original series, I have chosen as the lectotype the Darjeeling male, ex Coll. Schluginweit.

Usually, females from Burma and Siam have the three elongate spots beyond the fore-wing cell separated as in the Javanese subspecies *fruhstorferi* (Röb.) (Piepers & Snellen, 4, pl. xxiv, fig. 108 ♀) and not confluent as in the nominotypical form; in the female from Sandakan described below these fore-wing spots cannot be seen easily on account of the very broad black border.

A. camdeo camdana Cbt.

The female holotype of *A. camdeo camdana* Cbt. was taken in Malacca by Captain Pinwill and was recorded as "*Amblypodia antimuta*" by Butler (1877, *J. linn. Soc. Lond. Zool.* (ii) 1 : 548).

A very torn Malayan male may be described as under.

♂. Underside greyer-blue and less shining than is usual in *varro* Fruh., from the Karen Hills.

Underside pale hair-brown, with a faint ochreous sheen. Markings only slightly darker than the ground and arranged as in *varro*. Fore-wing 25 mm.

MALAY PENINSULA : Selangor, Bukit Kutu, 3485 feet, 18.ii.1931 (*A. S. Corbet*).

A. camdeo panthera subsp. n.

♀. Upperside mauve, slightly shining in a side light and with the discal areas becoming whiter. The fore-wing cell is closed by a rather large blackish-brown spot as in typical *camdeo*. The blackish-brown bordering is broader than in other races. On the fore-wing, it reaches the upper margin of the cell and becomes broader towards the apex : it is 4.5 mm. wide at the narrowest part along the termen and is continued for three-fifths of the distance along the dorsum. In the distal half of the fore-wing, the black border is rather diffuse and the veins are dark dusted. On the hind-wing, the border is lighter and has the inner edge more diffuse. The width of the border is 4.5 mm. at its narrowest part in space 4.

Underside with the markings arranged as in *varro* but the ground colour is darker and of a similar hue to that in Malayan *camdana*. Fore-wing 22.5 mm.

NORTH BORNEO : Sandakan (*Pryer*), ex Coll. Godman & Salvin. B.M. Rhop. Type No. 15059. Unique.

A. camdeo fruhstorferi (Röb.).

In the absence of sufficient comparative material, it is difficult to decide whether one male and two females from South-east Sumatra (Liwa, 9-1400 metres, 1890 (*W. Doherty*), ex Coll. Oberthür) are referable to a distinct subspecies or not. For the present, they are ranged under the Javanese race.

A. dispar Rly. & Godf.

In the subspecies *diluta* (Evans), from Burma, Maymyo, where the species is common, the male upperside is greyish-blue without a white discal patch on the fore-wing, and the female is broadly black bordered. In a male from the Southern Shan States, the fore-wing discal area is whitened and the ground colour beneath is almost pure white, except in the tornal half of the hind-wing, and the markings are dark as usual.

From Toungoo and the Karen Hills to the Ataran Valley the males decrease in size and the underside shows considerable variation : in females from Upper Assam and Tenasserim, the upperside is purple and much as in *diluta*, and the ground colour beneath is almost uniform, as in males from Toungoo and the Karens. Females from Kalaw and the Karens have much narrower black bordering on the upperside so that the black spot beyond the cell-end on the fore-wing is more prominent : in one Kalaw female, the ground colour above is white, with the basal halves of the wings dusted with pale blue, and the underside is entirely white with much reduced markings. In the male holotype of

dispar from North Siam, Prae (plate 1, fig. 8), the discal area on the fore-wing above is whitened.

From the above it will be seen that the species is very variable and it may be difficult to effect satisfactory separation from *A. camdeo* and *A. azata* Nic. These three species have similar male genitalia, although the holotype of *A. dispar* (the only example of the Siamese race examined), has a form of clasper different from the other races of *A. dispar*. The key given in Corbet (1941a: 152) for the separation of these species can be amplified to that given below.

- 6 (7). Un hair-brown with an ochreous hue and markings distinctly darker than the ground. UnH lower cell-end spot about $1\frac{1}{2}$ times as broad as the upper spot. UnH post-discal spots in spaces 6 and 7 approximately equal. *A. camdeo* (Mre.).
- 7 (8). Un hair-brown with the markings slightly darker than the ground. UnH upper and lower cell-end spots equal and in line. UnH post-discal spot in space 6 larger than the spot in space 7 *A. azata* Nic.
8. Un usually some shade of crimson-brown and usually a white streak above vein 6 on H; sometimes un mostly white. UnH lower cell-end spot nearly twice as broad as the upper spot and with its outer margin strongly convex. UnH post-discal spot in space 6 smaller than the spot in space 7 *A. dispar* Rly. and Godf.

aedias Group.

A. atosia udapa Cbt.

A male in the British Museum has the area of specialised scales slightly whitened (such variation occurs rarely in Neomalayan *A. atosia* and *A. epimuta*), and both wings have very broad black borders along the costa and termen, this bordering extending nearly to the cell-end on both wings. The wing shape, underside colour and pattern and genitalia appear to be identical with specimens of *A. atosia udapa* Cbt. The male in question is from Perak (*W. Doherty*) ex coll. Oberthür.

A. malayana B.Bakr.

Arhopala malayana Bethune-Baker, 1903, *Ent. mon. Mag.* 39: 218; ♂, Singapore.

This insect is known to me only from the original description, the type being lost. It appears to be nearest to *A. atosia* (Hew.), with which species the description of the underside agrees. It differs in the much larger size ("exp. alar., 52 mm."), and the upperside is stated to be "pale sublustrous mauvy-blue; quite dull and rather dark in some lights, bright and lustrous in others. Fine black bordering. Fore-wing lower end of cell has a large roundish patch of differently placed scales."

It is difficult to escape the conclusion that *malayana* is nothing more than a large specimen of *A. atosia udapa* Cbt.

A. semperi B.Bakr.

Arhopala semperi Bethune-Baker, 1896, in H. H. Druce, *Proc. zool. Soc. Lond.* 1896: 659, pl. xxix, fig. 9 ♂; ♂, South-east Borneo. (The female allotype, fig. 10, from Kina Balu, is a different species, possibly *A. eumolpus caesetius* Fruh. ♀.)

This species, which is figured in Seitz, pl. 150 f. 2 ♂, is known to me only from the original description, but there is little doubt that it pertains to the *aedias* group.

A. pseudomuta (Stgr.).*Amblypodia pseudomuta* Staudinger, 1889, *Deuts. ent. Z.*, "Iris," 2 : 125; ♂♀, Malacca.*Arhopala pseudomuta* (Staudinger), Bethune-Baker, 1903, *Trans. zool. Soc. Lond.* 17 : 87, pl. i, fig. 30 ♂.

Staudinger's description of this species was based on three males and a female in his own collection, but he identified the underside with that of the sexes of "*Narathura amphimuta* Felder" figured by Distant (1885 : 265, pl. xxi, fig. 9 ♀, 10 ♂). Staudinger's description is comparative, the Malaccan specimens being compared with *Arhopala allata* (Stgr.), from Palawan, which was then under description. The author correctly pointed out that Distant's "*amphimuta*" could not be reconciled with the Felders' original description of the species, as true *amphimuta* was tailless. Distant's poor figure of the male represents a species of the *democritus* group and not one of the *aedias* group: it cannot be reconciled with the *A. pseudomuta* figured by Bethune-Baker and so identified by later authors, including the present author.

Staudinger's reference to the much lighter vivid violet colour and the narrower black margin on the upperside in the male (as compared with *A. allata* male), and the vivid violet-blue upperside with narrower black outer band on the hind-wing in the female accords with *A. pseudomuta* B.Bak. et auctt. It is certain that Staudinger was not dealing with *A. atosia* because he goes on to say that this last-named species differs from its allies by a characteristic spot on the fore-wing (presumably alluding to that in space 4 of the post-discal fascia), and that Hewitson, in fact, had misidentified one of Staudinger's Malaccan males as *A. atosia*. Staudinger was in the habit of designating type specimens for his descriptions of new species and the holotype of his *pseudomuta* must be a specimen in his Malaccan series and not either of Distant's figures. Actually, there is little or no doubt regarding the identity of Staudinger's species, for it is practically certain that it was the type material from Malacca which Bethune-Baker described and figured (1896 : 662 and 1903 : 87, pl. i, fig. 30 ♂). Later authors, with the exception discussed below, have followed Bethune-Baker's identification of *A. pseudomuta*. A male from North Borneo included with the Malaccan series was described as "somewhat darker violet" by Staudinger and "decidedly bluer" by Bethune-Baker.

de Nicéville (1890 : 248, frontispiece, fig. 136 ♂) described *Arhopala rafflesii* from Singapore and cited the Distant figures of "*amphimuta*" (pl. xxi, figs. 9 & 10) which Staudinger had identified with his *A. pseudomuta*, for de Nicéville was clearly unaware of Staudinger's paper at this date. The type specimen of *A. rafflesii*, which was figured by de Nicéville, is in the British Museum and it pertains to the species known to all recent authors as *A. rafflesii*. This last-named species is in the *democritus* group and is not closely related to *A. pseudomuta* (Stgr.). Later, when de Nicéville (de Nicéville & Martin, 1896 : 465) became aware of Staudinger's paper, he sank his name *rafflesii* to *pseudomuta* Stgr. on the mistaken assumption that Staudinger's specimens agreed with Distant's figures. Bethune-Baker (1903 : 86) recognised the distinctness of *A. rafflesii* and correctly referred Distant's figures to de Nicéville's species.

A. allata (Stgr.).*Amblypodia allata* Staudinger, 1889, *Deuts. ent. Z.*, "Iris," 2 : 125; ♂♀, Palawan.

According to Bethune-Baker (1903 : 129), who examined Staudinger's types, Staudinger's figure 1 on plate ii does not represent this species. Bethune-Baker figured the male on plate iii, fig. 7 and the species is also figured by Seitz,

pl. 150 g 7 und. In Bethune-Baker and Seitz, the hind-wing underside is shown as having the post-discal spots in spaces 5, 4, 3 and 2 in a straight line: in all the specimens I have examined the spot in space 3 is much moved inwards while the spot in space 2 is slightly moved in.

epimuta Group.

A. epimuta epiala Cbt.

The Selangor Museum had a male of the Malayan race *epiala* from Perak (Road from Taiping to Selamir, vi.1930), in which the discal area on the fore-wing occupied by the modified scales is almost pure white. A female from Kedah (Gurun, xi.-xii.1915, *H. C. Robinson & C. B. Kloss*) is nearer the Burmese race *elsiei* (Evans): in this latter subspecies, the upperside is pale shining blue in both sexes, and the male fore-wing is slightly purple-washed and has broader black bordering than in Malaysia. I have seen no examples from the Langkawi Islands.

The Sumatran form agrees with the Malayan race, except that one of the three females in the British Museum has a broader black hind-wing border as in typical *epimuta* (Mre.) female. A single male in the British Museum, ex Coll. Moore, stated to be from Java, agrees with *epiala*. It is very doubtful if Piepers and Snellen's figure (pl. xxiv, fig. 113a ♂, b ♀) represents this species, as *Toxopeus* supposed: there is, in fact, no reliable evidence that the species occurs in Java.

A. tropaea Cbt.

A female from West Sumatra (Lebong Tandai, *C. J. Brooks*), with a fore-wing length of 13.5 mm. and with the upperside more purple and with rather broader black bordering than in the Malayan form, probably represents another race of this species but it would be impolitic to found a new race in this remarkably complex section of the *epimuta* group on a single female.

A. asia Nic.

Arhopala asia de Nicéville, 1892, *J. Bombay nat. Hist. Soc* 7: 333, pl. H, fig. 16 ♂; ♂, Malay Peninsula.

The type of *asia* is presumably in the Calcutta Museum and there is a little uncertainty regarding its identity. It was described as "Upperside, both wings deep dull purple without any gloss. Fore-wing with the costa and outer margin most narrowly black." As *A. amphimuta* (C. & R. Feld.) was not known to de Nicéville, the possibility of his having described the Felder species anew cannot be excluded. The figure of *asia* shows a pale blue upperside, with a slight violet tinge, and rather rounded fore-wings. *A. amphimuta* is purple, shining somewhat in a side light and with a broader black border. The species which I consider to represent de Nicéville's name is figured in Seitz, pl. 148 e 1 ♂ and is represented in the British Museum by a pair from Sumatra and a female without body from Labuan. The species was represented by a pair in the Selangor Museum.

A. agesias (Hew.).

There is a tendency, particularly in the female, for the underside markings to become smaller and fainter, thus approaching *A. similis* H. H. Drc., and it is difficult to identify some examples although examination of the genitalia serves to distinguish males.

democritus Group.

A. atrax (Hew.).

Amblypodia atrax Hewitson, 1862, *Cat. Lyc. B.M.* : 13, pl. vii, fig. 80, 82 ♀; ♂♀, "India."

The male holotype agrees with specimens from Johore and was probably taken on Mount Ophir by Wallace.

A. rafflesii Nic.

See the notes on this species under *A. pseudomuta* (Stgr.) on page 81.

aroa Group.

A. ace ace Nic.

Arhopala ace de Nicéville, 1892, *J. Bombay nat. Hist. Soc.* 7 : 329, pl. H, fig. 13 ♂; ♂, Perak.

The British Museum has three males and two females from North Borneo (Mount Kina Balu, 5.viii.1903, *J. Waterstradt*, ex Coll. Oberthür) : the males hardly differ from the typical form from Malaya and Sumatra but the female differs from an example of that sex from North-east Sumatra in the narrower black border running along the costal margin of the fore-wing and the three elongate, conjoined black spots visible beyond the cell-end spot.

A. agrata binghami subsp. n.

♂♀. In both sexes the fore-wing has the apex more pointed and the termen straighter than in the nominotypical form from Malaya. In the male, the upperside is paler and bluer, while the female is much bluer and has a more shining appearance than in *agrata* Nic. Underside as in *agrata*. Fore-wing ♂ 20.0 mm., ♀ 18.5 mm.

BURMA : Ye Valley, iii.1893 (*Col. Bingham*). B.M. Rhop. Type Nos. 15060 and 15061. This race is also represented in the British Museum from Maymyo, Dawnas, and Mergui.

A. alemon Nic.

Arhopala alemon de Nicéville, 1891, *J. Bombay nat. Hist. Soc.* 6 : 371, pl. F, fig. 20 ♂, 21 ♀; ♂♀, Burma.

The female of *A. alemon* was described and figured by Hewitson (1862, *Cat. Lyc. B.M.* : 13, pl. vii, fig. 80, 82) as the female of *A. atrax* (Hew.).

perimuta Group.

A. antimuta antimuta C. & R. Feld.

A large male from Singapore (19.xi.1936, *Major J. N. Eliot*, in Coll. Eliot) has a fore-wing length of 17 mm. as against the usual 15 mm. This specimen is deep lustrous blue above, bluer than in the Burmese race *tana* Cbt., but the underside markings and the genitalia are exactly as in nominotypical *antimuta*.

centaurus Group.

A. cooperi whiteheadi subsp. n.

♀. Upperside bluish purple, only very slightly shining bluish in a side light. Fore-wing and hind-wing black distal borders narrow (less than 2 mm. at vein 3 on the fore-wing and 1 mm. at vein 4 on the hind-wing), increasing towards the apices and continued along the costal margin of the fore-wing (narrowly) and the hind-wing (broadly). In the apical

area of the fore-wing, a black oblique wedge, which is contiguous on its outer edge with the inner edge of the black distal border, can just be distinguished. The fore-wing cell is closed by an obscure black spot. Differs from the Malayan race *gana* Cbt. in almost lacking the slight bluish sheen on the upperside, and in the less conspicuous subapical black wedge-shaped spot on the fore-wing. Underside as in Malayan *gana*. Fore-wing 17.0 mm.

BORNEO: Mount Kina Balu (*J. Waterstradt*), ex Coll. Bethune-Baker. B.M. Rhop. Type No. 15062. Named after John Whitehead, who explored Mount Kina Balu in 1887-1888.

A. corinda aceses Nic.

The British Museum has single females from West Sumatra (Lebong Tandai, iv.1923, *C. J. Brooks*, ex Coll. Joicey), British North Borneo (Mount Marapok, Dent Prov., ex Coll. van der Poll and ex Coll. Joicey) and West Java (Mount Gede, 4000 feet, viii.1892, *H. Fruhstorfer*, ex Coll. van der Poll and ex Coll. Joicey); these specimens differ very little from females from Malaya, except that the Sumatran example has narrower black borders.

A. eumolphus (Cram.).

Neither on the basis of male genitalia nor on facies does there appear to be any justification for separating *A. eumolphus* into two species as was done by *Toxopeus*.

It seems probable that *A. staudingeri* Semper (Seitz, pl. 150 d 1 ♂; Bethune-Baker, pl. ii, fig. 25 ♂) and *A. elagabulus* Fruh., misspelt "*heliogabalus*" in Seitz (Seitz, pl. 162 a 5 ♂), are species allied to *A. eumolphus* in the Philippines and New Guinea respectively.

A. horsfieldi basiviridis Nic.

Arhopala basiviridis de Nicéville, 1891, *J. Bombay nat. Hist. Soc.* 6 : 373, pl. G, fig. 22 ♂; ♂♀, Malay Peninsula.

de Nicéville's figure agrees with males from Malaya but not from Borneo and, as the insect was described from Malaya and Borneo, the first-named has been taken as the type locality.

A. horsfieldi serpa Fruh.

Arhopala horsfieldi serpa Fruhstorfer, 1899, *Stettin. ent. Ztg* 60 : 349; ♂, Nias.

Arhopala horsfieldi biru Fruhstorfer, 1914, *Deuts. ent. Z.*, "*Iris*," 28 : 126; Nias.

The Niasese race of *A. horsfieldi* should be known as *serpa* Fruh., the name *biru* Fruh. used in Seitz and by Corbet (1941a : 164) being a synonym.

agelastus Group.

A. agelastus agelastus (Hew.).

Amblypodia agelastus Hewitson, 1862, *Cat. Lyc. B.M.* : 12, pl. vi, fig. 61, 62, ♂ *nec* ♀; "India" (probably Singapore).

The very rare Malayan race has narrower black borders than in the subspecies *perissa* Doh., described from East Pegu, which flies from the Karen Hills to Mergui. In addition to the type, the British Museum has a male from Penang (1895, *Lakatt & Pamboo*, ex Coll. Oberthür) and a female from Singapore (*A. R. Wallace*, ex Coll. Joicey). It is very probable that the type specimen was collected by Dr. A. R. Wallace.

A. agelastus enoma subsp. n.

♂. Fore-wing apex more pointed and the termen slightly more crenulate than in sub-species *perissa* Doh., from East Pegu. Upperside paler and bluer and with the black costal border broader on both wings, that on the fore-wing nearly reaching the upper margin of the cell.

Underside much as in *perissa* but the post-discal fasciae are slightly broader. Forewing 17.5 mm.

SOUTH ANNAM : Xom-Gom, February (*H. Fruhstorfer*), ex Coll. Fruhstorfer. B.M. Rhop. Type No. 15063. A second male from Siam (Angkar, xii.1900, *H. Fruhstorfer*, ex Coll. Fruhstorfer) is similar.

A. labuana labuana B.Bkr.

Two Burmese males in the British Museum ("Birmanie," ex Coll. Oberthür and South Burma, Bankasoon, *A. O. Hume*, ex Coll. Godman & Salvin) are not separable from males from Neomalaya.

BIBLIOGRAPHY.

- BETHUNE-BAKER, G. T., 1896, in H. H. Druce, Further contributions to our knowledge of the Bornean LYCAENIDAE. *Proc. zool. Soc. Lond.* 1896 : 650-683.
- , 1903, A revision of the *Amblypodia* group of butterflies of the family LYCAENIDAE. *Trans. zool. Soc. Lond.* 17 : 1-164.
- CORBET, A. S., 1933, The bacterial growth curve and the history of species. *Nature* 131 : 61.
- , 1941a, A key to the Indo-Malayan species of *Arhopala* Boisduval (Lepidoptera : LYCAENIDAE). *Proc. R. ent. Soc. Lond.* (B) 10 : 149-183.
- , 1941b, The distribution of butterflies in the Malay Peninsula (Lepid.). *Proc. R. ent. Soc. Lond.* (A) 16 : 101-116.
- DISTANT, W. L., 1882-1886, *Rhopalocera Malayana*.
- FISHER, R. A., CORBET, A. S., and WILLIAMS, C. B., 1943, The relation between the number of species and the number of individuals in a random sample of an animal population. *J. anim. Ecol.* 12 : 42-58.
- MOLENGRAAF, G. A. F., 1921, Modern deep-sea research in the East Indian Archipelago. *Geog. J.* 57 : 95-121.
- MOULTON, J. C., 1915, The butterflies of Borneo, with notes on their geographical distribution, and keys for identification. *Sarawak Mus. J.* 2 : 197-266.
- DE NICÉVILLE, L., 1890, *The butterflies of India, Burmah and Ceylon*, 3 (Calcutta).
- DE NICÉVILLE, L., and MARTIN, L., 1896, A list of the butterflies of Sumatra with especial reference to the species occurring in the north-east of the island. *J. asiat. Soc. Bengal* 64 : 357-555.
- PIEPERS, M. C., and SNELLEN, P. C. T., 1918, *Rhopalocera of Java*, 4 (The Hague).
- SEITZ, A., 1926, *Die Gross-Schmetterlinge der Erde*, 9 : 947-967.
- WILLIAMS, C. B., 1944, Some applications of the logarithmic series and the index of diversity to ecological problems. *J. Ecol.* 32 : 1-44.
- ZEUNER, F. E., 1941, Geology, climate and faunal distribution in the Malay Archipelago. *Proc. R. ent. Soc. Lond.* (A) 16 : 117-123.
- , 1943, The biogeographic division of the Indo-Australian Archipelago. 7. The divisions as indicated by the distribution of insects in relation to geology. *Proc. linn. Soc. Lond.* 154 : 157-163.

EXPLANATION OF PLATES.

PLATE 1.

- FIG. 1. *Arhopala ijauensis ijauensis* B.Bak., Perak, ♀ holotype.
 2. *A. achelous achelous* (Hew.), British North Borneo, ♀.
 3. *A. anthelus grahami* Cbt., Perak, ♂ holotype.
 4. *A. anarte morphicolor* Cbt., Perak, ♂ holotype.
 5. *A. camdeo opalina* (Mre.), Khasi Hills, ♂ holotype.
 6. *A. camdeo camdana* Cbt., Malacca, ♀ holotype.
 7. *A. karennia* (Evans), Karen Hills, ♂ holotype.
 8. *A. dispar dispar* Rly. and Godf., North Siam, ♂ holotype.
 9. *A. dispar pendleburyi* Cbt., Pahang, ♀ holotype.
 10. *A. johoreana* Cbt., Johore, ♀ holotype.

PLATE 2.

- FIG. 11. *Arhopala azata* Nic., North-east Sumatra, ♂ holotype.
 12. *A. myrzala lammas* Cbt., Perak, ♂ holotype.
 13. *A. hellada ozana* Fruh., Malacca, ♀.
 14. *A. aedias agnis* C. & R. Feld., Malacca, ♀.
 15. *A. pseudomuta pseudomuta* (Stgr.), Perak, ♂.
 16. *A. allata pandora* Cbt., Singapore, ♂ holotype.
 17. *A. atosia udapa* Cbt., Perak, ♂.
 18. *A. similis* H. H. Dre., Perak, ♂.
 19. *A. agesias ovomaculata* (Hew.), Sumatra, ♂.
 20. *A. epimuta epiala* Cbt., Perak, ♂ holotype.
 21. *A. moorei busa* Cbt., Johore, ♂ holotype.
 22. *A. metamuta metamuta* (Hew.), Malacca, ♂.
 23. *A. hypomuta hypomuta* (Hew.), Pahang, ♂.
 24. *A. kurzi* (Dist.), Selangor, ♂.
 25. *A. wallacei wallacei* Cbt., Sumatra, ♂ holotype.
 26. *A. avatha* Nic., Perak, ♂.
 27. *A. moolaiana yajuna* Cbt., Sumatra, east coast, ♂.

PLATE 3.

- FIG. 28. *Arhopala agesilarus major* (Stgr.), Perak, ♂.
 29. *A. amphimuta amphimuta* (C. & R. Feld.), Singapore, ♂.
 30. *A. baluensis baluensis* B.Bak., Borneo, ♂.
 31. *A. asia* Nic., Sumatra, Palembang, ♂.
 32. *A. dajagaka* B.Bak., Borneo, Kina Balu, ♂.
 33. *A. zylda zylda* Cbt., West Sumatra, ♂ holotype.
 34. *A. zylda elioti* Cbt., Johore, ♂ holotype.
 35. *A. belphoebe belphoebe* Doh., Tavoy, ♂ holotype.
 36. *A. myrzalina* Cbt., Negri Sembilan, ♂.
 37. *A. democritus lycanaria* (C. & R. Feld.), Selangor, ♂.
 38. *A. alitacus pardenas* Cbt., Singapore, ♂ holotype.
 39. *A. atrax atrax* (Hew.), Johore, ♂ holotype.
 40. *A. ariana arianaga* Cbt., Perak, ♂ holotype.
 41. *A. rafflesii rafflesii* Nic., Penang, ♂.
 42. *A. anella* Nic., Johore, ♀.
 43. *A. silhetensis adorea* Nic., Singapore, ♂ holotype.
 44. *A. zambra zambra* Swinh., Tenasserim Valley, ♂ holotype.
 45. *A. apha aphadantas* Cbt., Malacca, ♂.

PLATE 4.

- FIG. 46. *Arhopala ace ace* Nic., Sumatra, ♂.
 47. *A. agrata agrata* Nic., Perak, ♂.
 48. *A. kounga ridleyi* Cbt., Singapore, ♂ holotype.
 49. *A. aroa aroa* (Hew.), Sumatra, ♂ holotype.
 50. *A. azinis* Nic. subsp., British North Borneo, ♀.
 51. *A. phaenops sandakani* B.Bak., Borneo, ♂ holotype.
 52. *A. agaba* (Hew.), Tavoy, ♂.
 53. *A. alea alea* (Hew.), Mergui, ♂.
 54. *A. alesia wimberleyi* (Nic.), Andaman Islands, ♀.
 55. *A. vihara vihara* (C. & R. Feld.), Malaya, ♂.
 56. *A. barami penanga* Cbt., Penang, ♂ holotype.
 57. *A. corinda acestes* Nic., Singapore, ♂.
 58. *A. cooperi cooperi* (Evans), Mergui, ♂ holotype.
 59. *A. bazalus zalinda* Cbt., Kedah, ♂ holotype.
 60. *A. aurea* (Hew.), West Sumatra, ♀.
 61. *A. trogon* (Dist.), Singapore, ♂.
 62. *A. eumolphus maxwelli* (Dist.), Singapore, ♀.
 63. *A. horsfieldi basiviridis* Nic., Sumatra, ♀.

PLATE 5.

- FIG. 64. *Arhopala arvina adalita* Cbt., Kedah, ♂ holotype.
 65. *A. epimete suedas* Cbt., Perak, ♂ holotype.
 66. *A. alaconia aloana* Cbt., Tavoy, ♂ holotype.
 67. *A. cardoni* Cbt., Perak, ♂ holotype.
 68. *A. wildeyana* Cbt., Singapore, ♂ holotype.
 69. *A. agesilaus gesa* Cbt., Langkawi Islands, ♂.
 70. *A. agelastus agelastus* (Hew.), Singapore, ♀.
 71. *A. asopia asopia* (Hew.), Moulmein, ♂ holotype.
 72. *A. labuana labuana* B.Bak., Borneo, ♂.
 73. *A. inornata inornata* (C. & R. Feld.), Perak, ♀ holotype of *brahma* B.Bak.
 74. *A. antimuta antimuta* C. & R. Feld., Perak, ♂.
 75. *A. perimuta regina* Cbt., Mergui, ♂.
 76. *A. paramuta* (Nic.), Karen Hills, ♂.
 77. *A. paraganesa birmana* (Mre.), Ataran Valley, ♂.
 78. *A. ariel ariel* (Doh.), Upper Assam, ♂ holotype.
 79. *A. ammonides ammonides* (Doh.), Tenasserim, ♂ holotype.
 80. *A. ammonides chunsu* Fruh., Perak, ♂.
 81. *A. ammon* (Hew.), Singapore, ♂ holotype.
 82. *A. ariel antis* Cbt., Johore, ♂ holotype.
 83. *A. abseus abseus* (Hew.), Perak, ♂.

PLATE 6.

- FIG. 84. *Arhopala diardi almansor* Fruh., Perak, ♂.
 85. *A. fulgida zohar* Fruh., Borneo, ♂.
 86. *A. anniella anniella* (Hew.), Singapore, ♂ holotype.
 87. *A. apidanus kartaphilus* Fruh., Singapore, ♂.
 88. *A. areste* (Hew.), Maymyo, ♂.
 89. *A. morphina morphina* (Dist.), West Sumatra, ♂.
 90. *A. fulla intaca* Cbt., Borneo, ♂ holotype.
 91. *A. caeca* (Hew.), Borneo, ♀.
 92. *A. belpheobe cowani* Cbt., Pahang, ♂ holotype upperside.
 93. *A. centaurus nakula* (C. & R. Feld.), Singapore, ♂.

PLATE 7.

- FIG. 94. *Arhopala agamemnon* Cbt., Singapore, ♂ holotype.
95. *A. metamuta metamuta* (Hew.), West Sumatra, ♂.
96. *A. muta maranda* Cbt., Singapore, ♂ holotype.
97. *A. moorei busa* Cbt., Johore, ♂ holotype.
98. *A. wallacei santava* Cbt., Singapore, ♂ holotype.
99. *A. tropaea* Cbt., Johore, ♂ holotype.
100. *A. bella* B.Bak., Johore, ♀ underside.
101. *A. metamuta metamuta* (Hew.), West Sumatra, ♀.
102. *A. muta maranda* Cbt., Pahang, ♀ allotype.
103. *A. moorei busa* Cbt., Johore, ♀ allotype.
104. *A. wallacei santava* Cbt., Singapore, ♀ allotype.
105. *A. tropaea* Cbt., Johore, ♀ allotype.
106. *A. kounga ridleyi* Cbt., Singapore, ♂.
107. *A. kounga ridleyi* Cbt., Singapore, ♀.
108. *A. aroa arops* Cbt., Perak, ♂ holotype.
109. *A. aroa arops* Cbt., Perak, ♀ allotype.
110. *A. phaenops phanda* Cbt., Singapore, ♂ holotype.
111. *A. phaenops phanda* Cbt., Singapore, ♀ allotype.



1



6



2



7



3



8



4



9



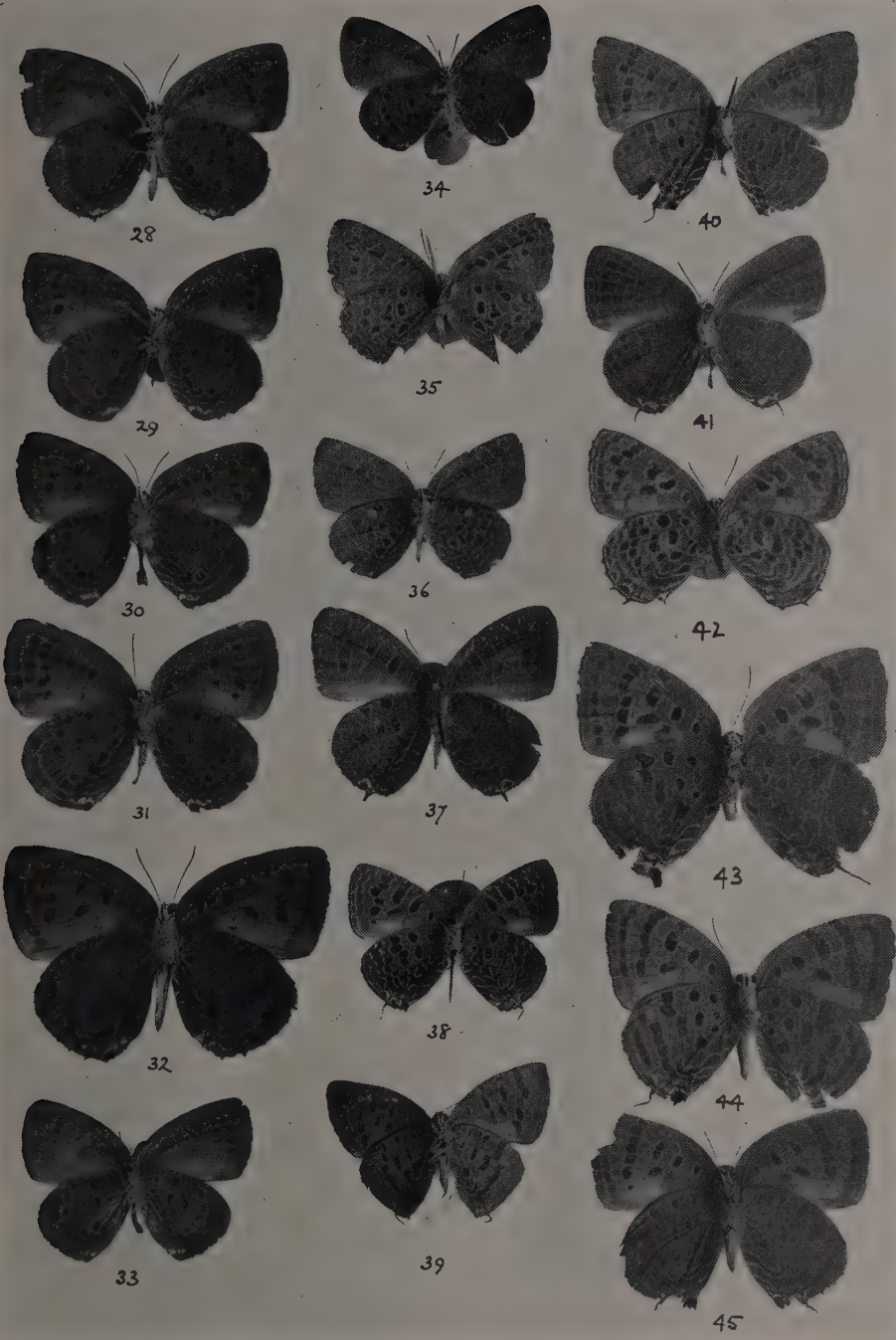
5



10



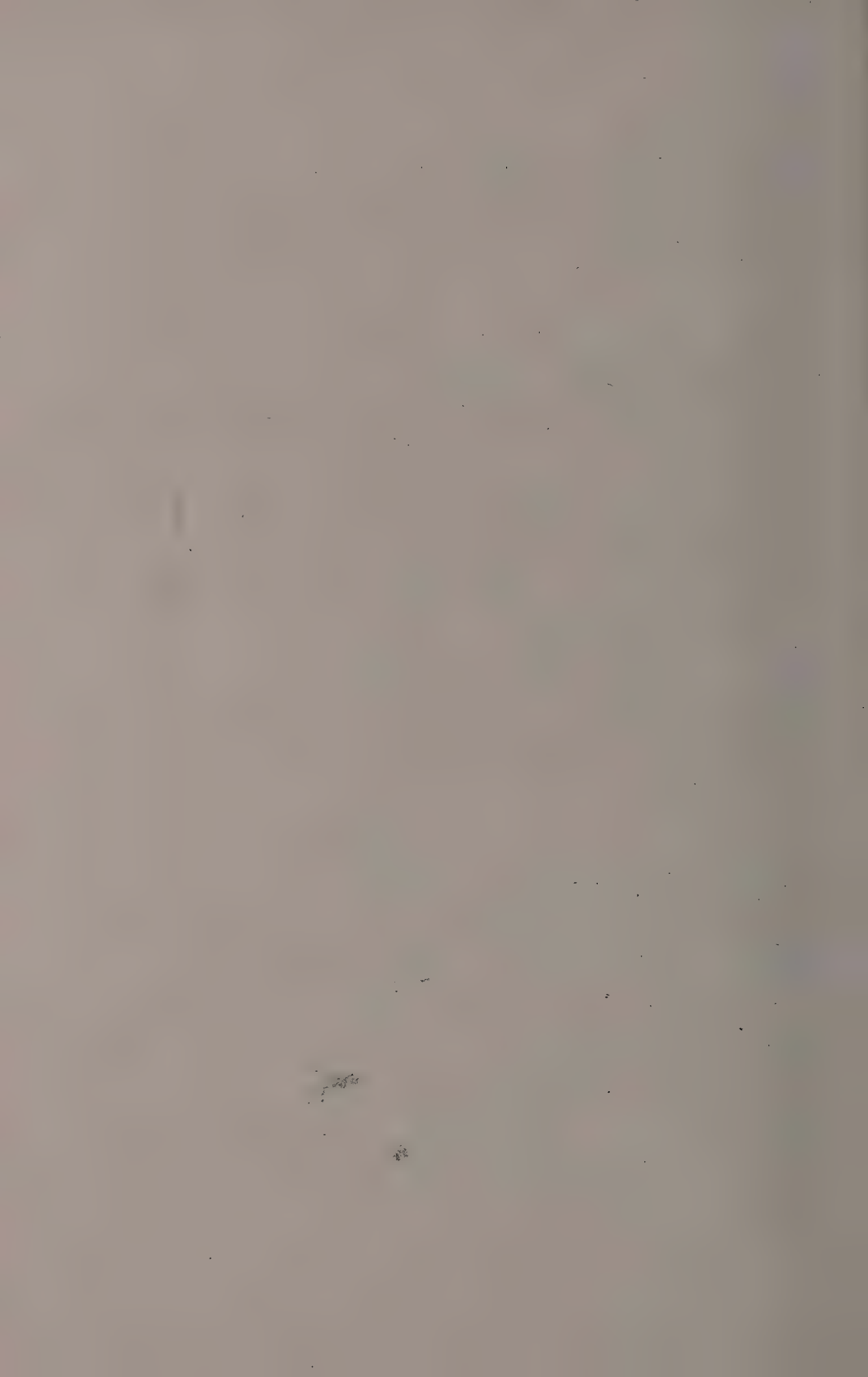
Indo-Malayan *Arhopala*.



Indo-Malayan *Arhopala*.

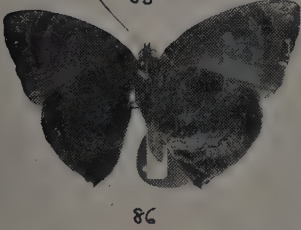


Indo-Malayan *Arhopala*.

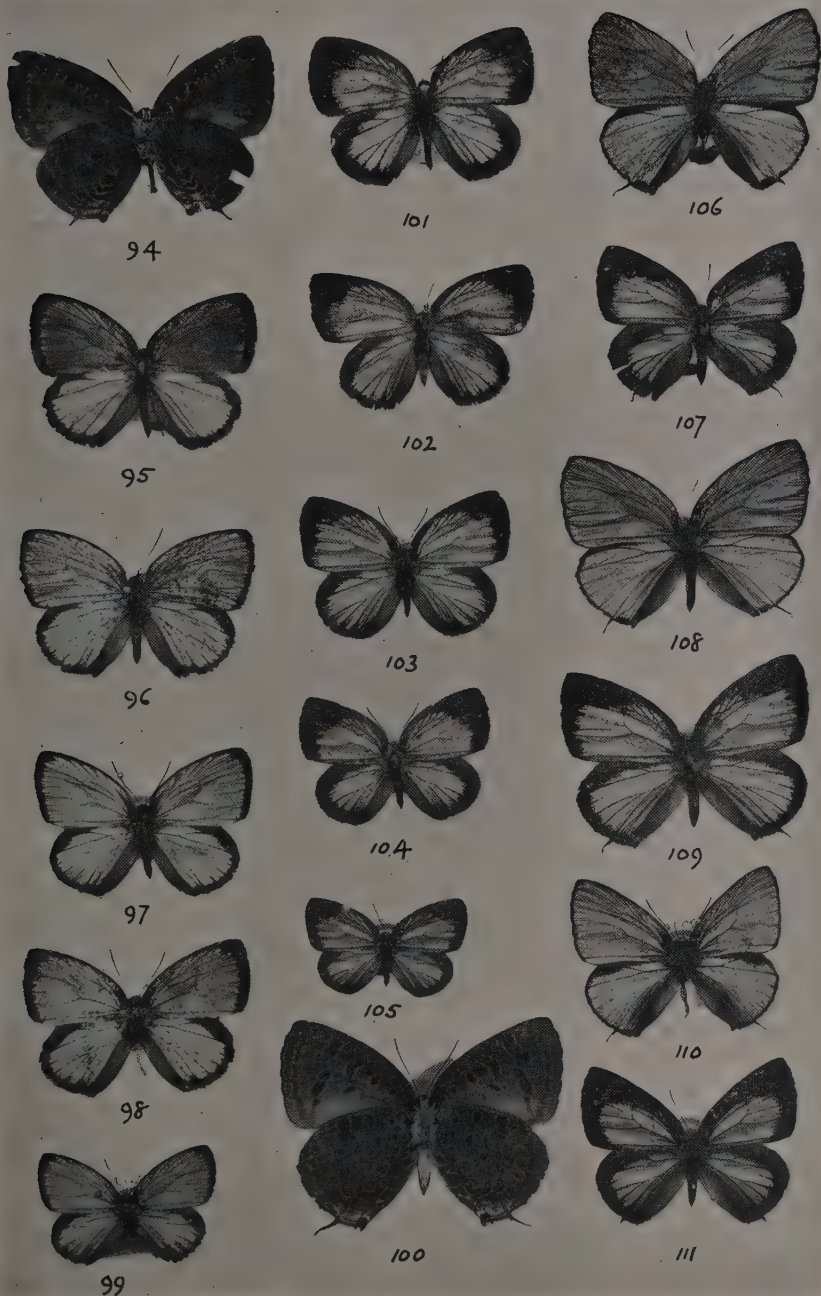




Indo-Malayan *Arhopala*.



Indo-Malayan *Arhopala*.



Indo-Malayan *Arhopala*.

Vol. 96. Part 6. Pp. 89-108, 39 figs.

15th May, 1946.

Eu. 344

THE
TRANSACTIONS
OF THE
ROYAL
ENTOMOLOGICAL SOCIETY
OF
LONDON

World List abbreviation: Trans. R. ent. Soc. Lond.

CONTENTS

	PAGE
BENSON, Robert B., M.A., F.R.E.S. · Classification of the CEPHIDAE (Hymenoptera Symphyta) . . .	89-108, 39 figs. ✓

LONDON:

PUBLISHED BY THE SOCIETY AND
SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 5s. 0d.

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Founded, 1833. Incorporated by Royal Charter, 1885.

PATRON—HIS MAJESTY THE KING.

OFFICERS and COUNCIL for the SESSION, 1946–1947.

PROF. G. D. HALE CARPENTER, M.B.E., D.M., *President*.

W. J. HALL, D.Sc.
C. B. WILLIAMS, M.A., D.Sc. } *Vice-Presidents*.
H. B. WILLIAMS, LL.D.

A. WELTI, *Treasurer*.

N. D. RILEY, *Secretary*.

Other Members of Council.

C. H. ANDREWES, F.R.S.	CAPT. R. A. JACKSON, R.N.
J. W. EVANS, M.A., D.Sc.	MISS C. E. LONGFIELD.
G. FOX-WILSON, N.D.H.	SIR GUY A. K. MARSHALL, K.C.M.G.,
R. M. GREENSLADE.	D.Sc., F.R.S.
FRANCIS HEMMING, C.M.G., C.B.E.	G. E. J. NIXON, B.A.
H. E. HINTON, B.Sc., Ph.D.	J. F. PERKINS, B.Sc.

F. J. GRIFFIN, A.L.A., *Registrar*.

Finance and House Committee.

G. FOX-WILSON, N.D.H. (*Chairman*).

J. W. EVANS, M.A., D.Sc.	W. RAIT-SMITH.
FRANCIS HEMMING, C.M.G., C.B.E.	O. W. RICHARDS, M.A., D.Sc.
H. E. HINTON, B.Sc., Ph.D.	

Publication and Library Committee.

W. J. HALL, D.Sc. (*Chairman*).

H. E. HINTON, B.Sc., Ph.D.	J. SMART, B.Sc., Ph.D.
B. M. HOBBY, M.A., D.Phil.	W. H. THORPE, M.A., Sc.D.
J. F. PERKINS, B.Sc.	

Committee on Generic Nomenclature.

FRANCIS HEMMING, C.M.G., C.B.E. (*Chairman*).

W. A. F. BALFOUR-BROWNE, F.R.S.E.	O. W. RICHARDS, M.A., D.Sc.
K. G. BLAIR, D.Sc.	N. D. RILEY (<i>Secretary</i>).

Committee for the Protection of British Insects.

H. M. EDELSTEN, O.B.E. (*Chairman*).

R. B. BENSON, M.A.	A. M. MASSEE, D.Sc.
E. A. COCKAYNE, M.A., M.D., F.R.C.P.	THE HON. MIRIAM ROTHSCHILD.
CAPT. R. A. JACKSON, R.N.	W. H. THORPE, M.A., Sc.D.
COL. F. A. LABOUCHERE.	N. D. RILEY (<i>Secretary</i>).

The Executive Officers of the Society are *ex-officio* members of all Committees.

DELEGATES OF THE SOCIETY TO :

- 1. British National Committee for Biology (Royal Society).**
Mr. Francis Hemming, C.M.G., C.B.E., appointed 1945.
Dr. V. B. Wigglesworth, M.A., B.Ch., M.D., F.R.S., appointed 1943.
- 2. Local Committee of Management of Wicken Fen.**
Mr. H. M. Edelsten, O.B.E. [nominated by Committee for the Protection of British Insects].
- 3. National Trust for Places of Historic Interest or Natural Beauty.**
Mr. H. M. Edelsten, O.B.E., appointed 1944.
- 4. New Forest Association.**
Mr. W. Fassnidge, appointed 1934.
- 5. New Forest Joint Committee.**
Mr. W. Fassnidge, appointed 1939. *Dr. F. J. Killington, D.Sc., A.L.S., appointed 1939.*
- 6. Royal Meteorological Society. Phenological Committee.**
Dr. C. B. Williams, M.A., D.Sc., appointed 1937.
- 7. Biology War Committee.**
Prof. P. A. Buxton, M.A., F.R.S., appointed 1941.
- 8. Council for the Promotion of Field Studies.**
Dr. W. H. Thorpe, M.A., Sc.D., appointed 1944.
- 9. Joint Bioclimatic Committee.**
Dr. B. P. Uvarov, C.M.G., D.Sc., appointed 1945.
Dr. C. B. Williams, M.A., D.Sc., appointed 1945.

CLASSIFICATION OF THE CEPHIDAE (HYMENOPTERA SYMPHYTA)

By Robert B. BENSON, M.A., F.R.E.S.

Manuscript received 27th February, 1945.

(Read 2nd May, 1945.)

WITH THIRTY-NINE TEXT-FIGURES.

CONTENTS.	PAGE
CEPHIDAE and SYNTEXIDAE	89
Basis of the present Study	90
The Approach to a sounder Classification	90
Instability in Wing Venation	91
Instability in the Number of tibial Spines	91
CEPHIDAE : Key to Subfamilies and Tribes	91
CEPHINAE : Key to Genera of Hartigiini: <i>Hartigia</i> , <i>Caenocephus</i> , <i>Janus</i> (<i>J. malaisei</i> sp. n.), <i>Syrista</i> , <i>Cephalocephus</i> gen. n. (<i>C. xanthus</i> sp. n.).	93
Key to Genera of Pachycephini: <i>Pachycephus</i> and <i>Characopygus</i>	101
Key to Genera of Cephini: <i>Calameuta</i> , <i>Cephus</i> and <i>Trachelus</i>	102
ATHETOCEPHINAE : <i>Athetocephus</i>	105
Summary of Host-plants of CEPHIDAE	105
List of British CEPHIDAE	106
Phylogeny of CEPHIDAE (with Table to show World-distribution)	106
References	107

CEPHIDAE and SYNTEXIDAE.

In 1935 I wrote a preliminary analysis of the genera of the CEPHIDAE of the world. That paper was mainly concerned with defining the limits of the family to include some forms recently found in Madagascar, the first ever found in the southern hemisphere, and to exclude the anomalous genus *Syntexis*. For *Syntexis* was erected a new family SYNTEXIDAE, related to the XIPHYDRIDAE; this family name was based on the assumption that the name *Syntexis* had been derived from the Latin noun of the same spelling with stem "syntex-" (= "wasting away," or, "consumption"). In the meantime Ross had come to similar conclusions about excluding *Syntexis* from the CEPHIDAE, but did not publish his results until 1937, when he changed the family name to SYNTECTIDAE on a different interpretation of the Latin origin of the name *Syntexis*. In the absence of any statement on the derivation of the generic name in the original publication (Rohwer 1915), the family name SYNTEXIDAE should stand as it has priority.

The earlier paper was naturally mainly concerned with the diagnostic characters of the family. Attention was there drawn to the apocrita-like apical constriction of the first abdominal segment, giving the abdomen an up-down flexibility, and the absence of the metanotal wing-locking device, found in all other sawflies. Ross (1937), largely on these bases, erected a new superfamily, Cephioidea, for the reception of the CEPHIDAE alone. It seems probable that these two characters are functionally related.

Basis of the present Study.

Just before the present war Dr. René Malaise sent me two Cephids collected by him in N.E. Burma in 1934, one of them belonging to a undescribed genus. The study of these specimens led to a further comparative study of Cephid genera and provides an opportunity of revising the former classification of the family with the help of much additional material and the careful faunistic studies of other workers.

Since 1935 the British Museum collections have been enriched by long series of *Pachycephus smyrnensis* J. P. F. Stein and *Trachelus libanensis* (André) collected in Cyprus by Mr. G. A. Mavromoustakis, and by specimens of several Russian and Asiatic species received in exchange with Dr. V. V. Gussakovskii and previously unrepresented in our collections. Furthermore reference can now be made to Ries's (1937) careful study of the nearctic CEPHIDAE and I have had the benefit of long correspondence with him. Takeuchi (1938) has also made a careful study of the Japanese CEPHIDAE, Gussakovskii (1935) has published his revision of the palaearctic species, and the part of the *Hymenopterorum Catalogus* dealing with the CEPHIDAE and SYNTAXIDAE has also appeared (Klima 1937).

Despite all this, the material which has been available in the British Museum is quite inadequate for any attempt at a monographic study, lacking, as it does, representatives of numerous described Eurasian species and even genera (such as *Pseudocephus*) while vast areas of Asia still remain unexplored for CEPHIDAE. For information about *Caenocephus* and for the gift of a representative of this genus to the British Museum I have pleasure here in thanking Dr. J. Chester Bradley of Cornell University.

As to the biology, very much still remains to be done. In several of the genera and even some of the larger groups (*i.e.* ATHETOCEPHINAE and Pachycephini of the CEPHINAE) no information even as to host-plants is yet available, and it is impossible to guess in what way this information might colour the final picture.

The Approach to a sounder Classification.

In the earlier paper numerous new characters were introduced for grouping the species into genera; some of these, such as the form of the claws and the mandibles, have since proved their value.

In the present study several other new characters are introduced, including at least one, the shape of the supraclypeal area, which seems now to be extremely important. Some of the characters formerly used appear now to be too variable to be of much value. Two of these, the number of pre-apical tibial spines and the presence or absence of cross-veins in the wings, will be discussed in more detail later. Other characters which have been emphasized before seem, in some groups, to cut across the main body of correlated characters; they are presumably then unreliable as expressions of wider affinity in these groups and justify the discarding of numerous trivial genera. All these characters are sufficiently dealt with in the two headings that follow and in the keys.

The results of these studies are mainly the establishing of clearly defined groups based on a correlation of previously neglected characters, the fusion together of the more trivial "genera" within these groups, and, at the same time, the usual re-sorting of species. The modern systematist, with an elementary knowledge of genetics, is not likely to be content with any groupings unless they are based on the correlation of several characters; he will be suspicious

of any group based entirely on the correlation of a single morphological character with the vanity of the author who defined it!

Instability in Wing Venation.

In the series of *Trachelus libanensis* (André) collected by G. A. Mavroumoustakis in Cyprus considerable instability is shown in the presence of the third transverse cubital vein (intercubitus) in the fore-wing or the transverse cubital vein (intercubittella) in the hind-wing in either sex. If one designates a capital letter to indicate the presence of the third transverse cubital vein in the fore-wing (L = left, R = right) and a small letter to indicate the presence of a transverse-cubital vein in a hind-wing (l = left, r = right), the normal wing-formula would be LRLr. The 90 specimens of this species in the British Museum can then be tabulated thus: 70LRLr; 3-Rlr; 3-lr; 3—; 2LRL-; 2LR-l; 7LR—. Nor is this confined to Cephini; Takeuchi mentions that the Japanese *Janus piri* (Okamoto & Muramatsu) regularly lacks the transverse cubital vein in its hind-wings. Care must be taken therefore in attaching much importance to the absence of veins in the unique specimen forming the basis of *Neateuchopus* or the three or four specimens forming the basis of *Caenocephus*.

Instability in the Number of tibial Spines.

Ries, by amassing much more material than I ever had, has been able to demonstrate the instability of the number of pre-apical tibial spines in such genera as *Calameuta*, *Cephus* and *Trachelus*. Among 200 *Cephus pygmaeus* (L.), for example, 130 were found to have two pre-apical spines on each hind tibia, 55 has only one on each hind tibia, while 15 had one spine on one side and two on the other. This discovery invalidates the main character on which *Pseudocephus* was based, as it was erected to contain those species of *Cephus* which had only one of these spines on each hind tibia.

Nor is this instability limited to the Cephini; *Janus* is sometimes but one-spined and it now seems that *Hartigia* may have two spines (see below). The pre-apical tibial spines are thus apparently not very reliable clues to relationship in CEPHIDAE.

CEPHIDAE Haliday.

Cephites Newman, 1834, *Ent. Mag.* 2: 411.

CEPHIDAE Haliday, 1839, *Hymenoptera Britannica*, 2, *Hymenopterorum Synopsis*: i.

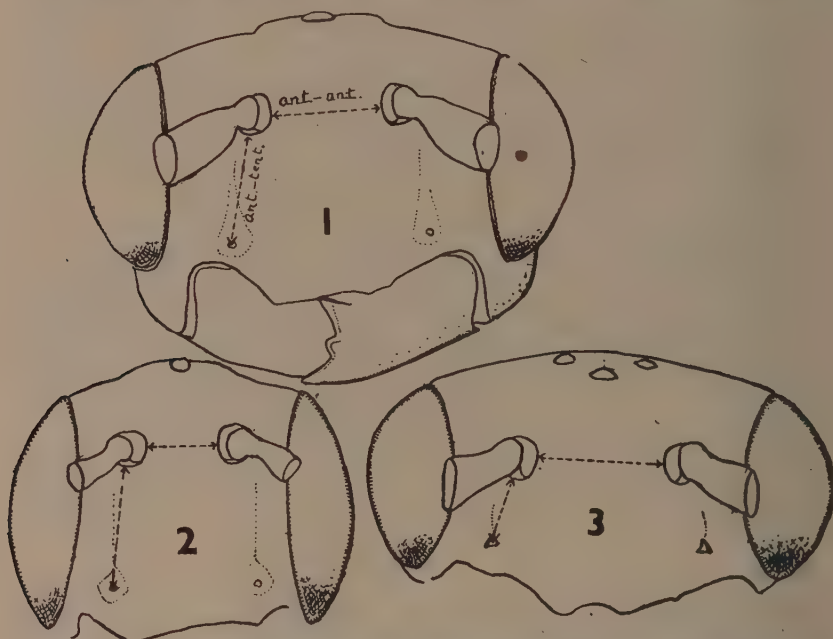
Key to Subfamilies and Tribes.

1. Labial palps 3-segmented (without a sensory pit), but longer and stouter than the setaceous maxillary palps which are 4-segmented (fig. 5). Fore-wing with intercostal area unthickened and with same transparency as rest of wing-membrane (fig. 22); hind-wing with 11-15 hamuli on mid-fore margin (fig. 25). ♀ saw-sheath strongly curved up so that the apex is erect (fig. 29).

Head without genal carina on lateral hind margin, grotesquely swollen and rounded behind the eyes, so that the front ocellus is $2\frac{1}{2}$ times farther from the hind margin of the head than from an antennal socket; face broad, with the distance between the antennal sockets (ant.-ant.) twice the distance between an antennal socket and the nearest anterior tentorial pit (ant.-tent.) (cf. fig. 3). Transverse radial vein in fore-wing emerges from near the middle of the lower margin of the stigma.

♂ with 8th sternite bearing a fringe of modified flattened setae (fig. 39); genitalia with penis-valves free (not united together).

- [1 genus, *Athetocephus* Benson, with two species, confined to Madagascar. Biology unknown.] 2. *ATHETOCEPHINAE*.
- . Labial palps 4-segmented (with a large sensory pit on the 4th) and shorter than the 6-segmented maxillary palps (fig. 4). Fore-wing with the intercostal area less transparent than the rest of the wing-membrane (figs. 23-24); hind-wing with 6-9 hamuli on the mid fore-margin (fig. 26). ♀ saw-sheath with the main axis almost straight or curved down (figs. 30-33). Head with genal carina developed (except in certain spp. of *Pachycephus*); front ocellus not more than twice as far from back of head as from antennal socket (except in *Cephalocephus* and certain species of *Janus*). Face medium (with the distance between the antennal sockets (ant.-ant.) about



FIGS. 1-3.—Face to show supraclypeal area, defined as ratio of distance between antennal sockets (ant.-ant.) and distance between an antennal socket and the middle of the anterior tentorial pit on the same side (ant.-tent.) in the genotypes of *Cephus* (fig. 1), *Calameuta* (fig. 2) and *Pachycephus* (fig. 3).

- equal to the distance between an antennal socket and its nearest anterior tentorial pit (ant.-tent.) or face long (ant.-tent. greater than ant.-ant.) and face only broad (ant.-ant. greater than ant.-tent.) in *Pachycephini* (figs. 1, 2 and 3). Transverse radial vein of fore-wing nearer apex than base of stigma. Confined to Northern Hemisphere. 1. *CEPHINAE* 2.
2. Ant.-ant. from $\frac{1}{2}$ to 1 as long as ant.-tent. (figs. 1 and 2); head from above often less than twice as broad as the side is long; left mandible with long outer and inner tooth, with or without a short middle tooth between these two main teeth (figs. 10-13). Apical ♂ sternite not constricted before apex (figs. 37 and 38) 3.
- . Ant.-ant. $1\frac{1}{3}$ to 2 as long as ant.-tent. (fig. 3); head from above about twice as broad as the length at the side (fig. 14); left mandible stout with a long

outer tooth and two short inner teeth of almost equal prominence (fig. 9). Apical ♂ sternite constricted before apex where it is lobed (fig. 36). [Claws gradually curved, with the sub-apical tooth not noticeably longer and stouter than the end tooth (fig. 20); hind basitarsus approximately equal to 3 following tarsal segments together. Antenna with 15-22 segments; flagellum sub-clavate, thickening gradually after the 2nd-3rd segment, but tapering towards apex. Maxillary palp is normal, with segment 6 shorter than 4 and emerging from near apex of 5. Eye about $1\frac{1}{2}$ times higher than long. Hind tibia with 2 pre-apical spines. ♀ saw-sheath with main axis straight and about $\frac{2}{3}$ as long as basal plate. ♂ genitalia with penis-valves free, not fused together.

2 genera: *Pachycephus* Stein and *Characopygus* Konw. Mediterranean and Eurasian Steppes. Biology unknown.] . ii. *Pachycephini* trib. n.

3. Antenna (19-36 segmented) with 3rd segment usually longer than 4th; flagellum constricted only for less than basal $\frac{1}{4}$, and thick—gradually and slightly after 2nd flagellar segment. Eye variable in shape. Claws curved sharply, almost angled in the middle, with the sub-apical tooth longer and stouter than the apical tooth, and usually with a basal lobe or 3rd tooth as well (figs. 17 and 19); hind basitarsus at least almost as long as the 3 following tarsal segments together. ♀ saw-sheath at least with its main axis slightly down-curved (fig. 30) (except in *Cephalocephus* (fig. 31)); ♂ with at most a fringe of modified setae on apex of 8th sternite and penis-valves free, not fused together. 5 genera: *Caenocephus* Konw., *Cephalocephus* gen. n., *Hartigia* Schiödtte, *Janus* Stephens and *Syrista* Konw. Holarctic. So far as known attached to Rosaceae and other arborescent Dicotyledones i. *Hartigiini*.

- . Antenna (16-24 segmented) never with 3rd segment longer than 4th; flagellum with apical $\frac{1}{4}$ subclavate, and usually with at least the 4 basal segments unthickened (except *Trachelus*). Eye about $1\frac{1}{2}$ times higher than long. Claws evenly curved, with the sub-apical tooth shorter and thinner than the end tooth and with no basal lobe or 3rd tooth present (fig. 21); hind basitarsus clearly shorter than 3 following tarsal segments together. ♀ saw-sheath with the main axis straight (figs. 32 and 33); ♂ 8th sternite often with patches of modified setae, sometimes in definite cavities (figs. 37 and 38); penis-valves fused together for at least the apical $\frac{1}{2}$ of their length.

3 genera: *Calameuta* Konw., *Cephus* Latr. and *Trachelus* Jurine.

Holarctic, but concentrated in Eurasian Steppes. Attached to Gramineae.

iii. *Cephini*.

i. Subfamily CEPHINAE Kirby.

CEPHINAE W. F. Kirby, 1882, *List. Hym. Brit. Mus.* 1: 353.

ii. Tribe Hartigiini.

Macrocephides Konow, 1899, *Ent. Nachr.* 25: 74.

HARTIGIINAE Enslein, 1914, *Ins. Mitteleurop* 3: 195.

Macrocephini Enslein, 1918, *Tenthred. Mitteleurop*: 684.

Key to Genera of Hartigiini.

1. Hind tibia with 1-2 pre-apical spines. Hind-wing with a closed cubital cell. Antenna with more than 20 segments. ♀ cercus less than $\frac{1}{3}$ length of saw-sheath. 2.
- . Hind tibia without a pre-apical spine. Hind-wing without a closed cubital cell. Antenna with only 19 segments and shorter than head and thorax together. ♀ cercus more than $\frac{1}{3}$ length of saw-sheath. [Left mandible without a middle tooth or lobe between the 2 main teeth; maxillary



FIGS. 4 and 5.—Maxillary and labial palps in *Cephus* (fig. 4) and *Athetocephus* (fig. 5).



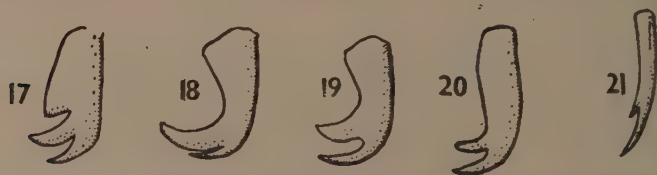
FIGS. 6-8.—Maxillary palp in *Hartigia* (fig. 6), *Syrista* (fig. 7) and *Janus* (fig. 8).



FIGS. 9-13.—Left mandible in *Pachycephus* (fig. 9), *Cephus* (fig. 10), *Janus* (fig. 11), *Syrista* (fig. 12) and *Cephalocephus* (fig. 13).



FIGS. 14-16.—Head from above in *Pachycephus* (fig. 14), *Cephalocephus* (fig. 15) and *Janus* (fig. 16).



FIGS. 17-21.—Tarsal claw in *Janus* (fig. 17), *Athetocephus* (fig. 18), *Syrista* (fig. 19), *Pachycephus* (fig. 20) and *Cephus* (fig. 21).

palp with 4th segment about $1\frac{1}{2}$ times as long as 6th, which emerges from about middle of 5th (as in *Syrista*, fig. 7); eyes about as far apart in front as the height of an eye; eye with length to height as about 1.0:1.5-1.6; ant.-ant. to ant.-tent. as about 1.0:1.1. Claws with enlarged rounded basal lobe.

Biology unknown. 2 species. E. Asia and N.W. America.]

2. *Cænocephus* Konow.

2. Claws with only a slight basal lobe. Maxillary palp with 6th segment emerging from middle or near apex of 5th 3.
 -. Claws with a prominent basal lobe acute at apex (fig. 17). Maxillary palp with 6th segment emerging from near base of 5th, which is thus a mere flap (fig. 8). [Anal vein of fore-wing clings to the hind margin of the wing and the vanal fold, not being separated therefrom by more than twice breadth of vein (fig. 27); radius of fore-wing often absolute just before it joins the stigma and directed towards a point on the stigma some distance from the base of the stigma (fig. 24). Front ocellus about twice as far from the back of the head as from an antennal socket; left mandible with a basal shoulder to the inner of the two main teeth (fig. 11); antenna with 20-28 segments; maxillary palp with 4th segment about $1\frac{1}{2}$ times as long as 6th; head about $1\frac{1}{2}$ times as broad as the length of a side (fig. 16); eye almost circular in outline (length to height as about 1.0:1.2-1.3). Hind tibia with 1-2, generally 2, pre-apical spines. Saw-sheath not more than $\frac{3}{4}$ length of oblong plate; saw with truncated or bicuspid teeth. 13 species. Holarctic and Oriental. Attached to arborescent plants of various orders such as Rosaceae, Grossulariaceae, Fagaceae, Salicaceae, etc.]

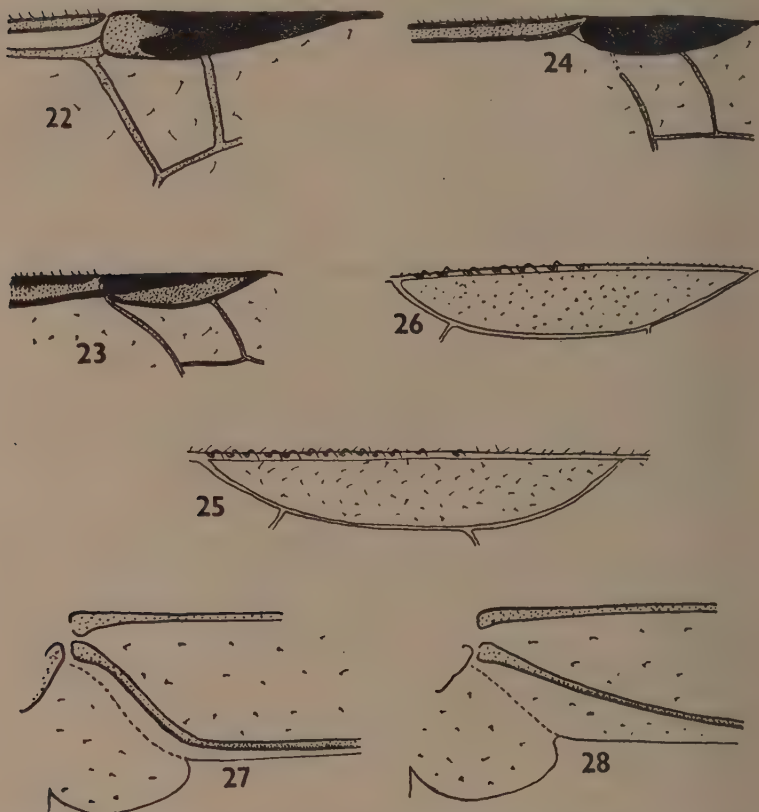
3. *Janus* Stephens.

3. Head at most little more than $1\frac{1}{2}$ times broader than long (cf. figs. 15 and 16); left mandible bidentate without intermediate lobe (figs. 12 and 13); maxillary palp with segment 4 about $1\frac{1}{2}$ times as long as 6; antenna with 26-36 segments. Hind tibia with two pre-apical spines. Cross-vein to anal cell in fore-wing present or absent. Europe and E. Asia 4.
 -. Head almost twice as broad as long at the side (cf. fig. 14); left mandible with an intermediate lobe between the two main teeth (cf. fig. 11); maxillary palp short with segment 4 not longer than 6 (fig. 6) (except in *H. nigrata* (Down.)); antenna with 22-25 segments. Hind tibia usually with but one pre-apical spine. Cross-vein to anal cell in fore-wing always present. [Eye less than $1\frac{1}{2}$ times higher than long (c. 1.4:1.0). Saw-sheath about $\frac{3}{4}$ length of oblong plate. 13 species. Holarctic. Attached mostly to herbaceous or shrubby Rosaceae.] 1 *Hartigia* Schiödt.
 4. Head not abnormally swollen behind the eyes (front ocellus not more than twice as far from back of head as from an antennal socket); ant.-tent. less than $1\frac{1}{2}$ ant.-ant.; 6th segment of maxillary palp emerges from middle of 5th (fig. 7). ♀ saw-sheath down-curved and at least $\frac{3}{4}$ length of oblong plate and $1\frac{1}{2}$ as long as hind basitarsus. Black species with red-banded abdomen. 2 species. Palearctic. Attached to *Rosa* . . . 4. *Syrista* Konow.
 -. Head grotesquely swollen behind the eyes (fig. 15) (front ocellus about 3 times farther from back of head as from an antennal socket); ant.-tent. twice ant.-ant. (cf. fig. 2); 6th segment of maxillary palp emerges from near the apex of the 5th (cf. fig. 4). Saw-sheath slightly curved up and only $\frac{3}{8}$ length of oblong plate (fig. 31) and $\frac{2}{3}$ length of hind basitarsus, tapering behind in dorsal aspect. Body mainly yellow with black markings. ? 2 species. Oriental. Biology unknown.

[Antenna with 32 segments, thickening gradually from after 4th; 3 longer than 4th; left mandible bifid with the inner tooth nearly twice as long as the outer tooth (fig. 13); maxillary palp with 4th segment about $1\frac{1}{2}$ times as long as 6th. Hind tibia with 2 pre-apical spines and basitarsus much

longer than 3 following tarsal segments together; claws with very slight basal swelling. Type: *Cephalocephus xanthus* sp. n. N.E. Burma.]

5. *Cephalocephus* gen. n.



FIGS. 22-24.—Portion of right fore-wing to show relationship between radial and transverse radial veins to stigma and the form of the intercostal area in *Athetocephus* (fig. 22), *Cephus* (fig. 23) and *Janus* (fig. 24).

FIGS. 25 and 26.—Front margin of radial cell in hind-wing to show hamuli in *Athetocephus* (fig. 25) and *Cephus* (fig. 26).

FIGS. 27 and 28.—Anal region of fore-wing in *Janus* (fig. 27) and *Cephus* (fig. 28).

Hartigia Schiödte.

Hartigia Schiödte, 1838, *Natur. Tidskr.* 2: 332 (no species named).

Hartigia Boie, 1855, *Ent. Ztg. Stettin.* 16: 49. (Genotype: *Astatus satyrus* Panzer (monobasic) = *Hartigia nigra* (Harris).)

Cerobractus O. Costa, 1860, *Fauna Regno Napoli*, Imen. 3, Cefidei: 9. (Genotype: *Cerobractus major* O. Costa (monobasic) = *Hartigia nigra* (Harris).)

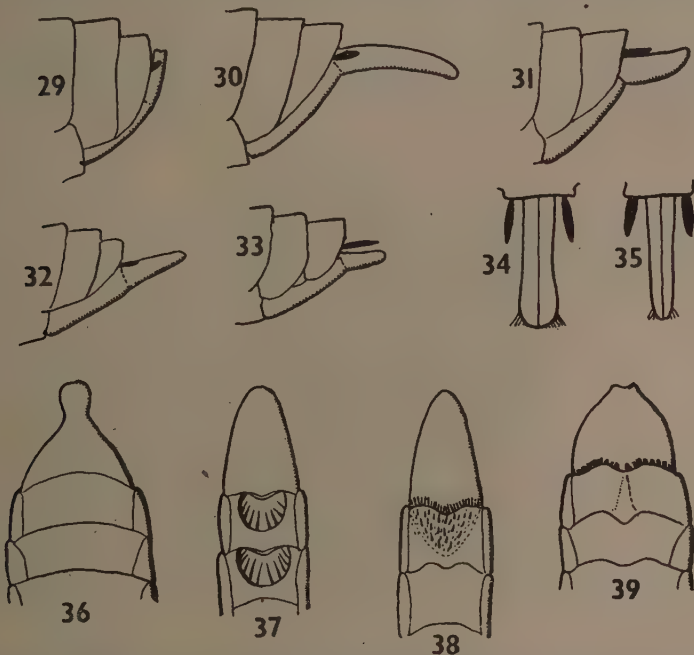
Macrocephus Schlechtendal, 1878, *Ent. Nachr.* 4: 153. (Genotype: *Macrocephus ulmariae* Schlechtendal (monobasic) = *Hartigia nigra* (Harris).)

Cephosoma Grادل, 1881, *Ent. Nachr.* 7: 294. (Genotype: *Cephosoma syringae* Grادل (monobasic) = *Hartigia nigra* (Harris).)

Adirus Konow, 1899, *Ent. Nachr.* 15: 74. (Genotype: *Cephus trimaculatus* (Say). Monobasic.)

Paradirus Dovnar-Zapolskii, 1931, *Annu. Mus. zool. Acad. Sci. Leningrad* 32: 39. (Genotype *Paradirus algiricus* Dovnar-Zapolskii. Monobasic) = *Hartigia algirica* André.

Gussakovskii, in exchange, very kindly sent to the British Museum a specimen of *Pachycephus nigratus* Down. Gussakovskii (: 350) has already transferred this species to *Janus*. On the basis of the specimen sent to the British Museum this species does not belong to *Janus* either, but agrees closest with *Hartigia*, to which it is here transferred. It differs, however, from all other described *Hartigia* (except *H. gigantea* (Enderlein) Takeuchi) in having two pre-apical hind tibial spines, and also in that the 4th segment of the maxillary palp is elongate, as in most other CEPHIDÆ, being about twice as long as the 6th. Gussakovskii (: 350) says that the species in the field is associated with



FIGS. 29-33.—Apex of female abdomen from the side to show curvature of saw-sheath and relative lengths of cercus, saw-sheath and oblong plate in *Athetocephus* (fig. 29), *Syrista* (fig. 30), *Cephalocephus* (fig. 31), *Cephus* (fig. 32) and *Calameuta* (fig. 33).

FIGS. 34 and 35.—Apex of saw-sheath from above in *Trachelus* (fig. 34) and *Cephus* (fig. 35).

FIGS. 36-39.—Apex of male abdomen from beneath in *Pachycephus* (fig. 36), *Trachelus* (fig. 37), *Cephus* (fig. 38) and *Athetocephus* (fig. 39).

leaves of *Phlomis salicifolia* Regel (Labiateae). If this should prove to be the host-plant, the species has diverged from the general host-association of the genus, which, so far as is known, is with herbaceous or shrubby Rosaceae, and it would suggest that the morphological differences are of sufficient significance to justify its separation into a distinct genus. Furthermore it seems very unlikely that *H. gigantea* (Enderlein) really belongs here; to judge from its original description it should probably go in another new genus.

Representatives of the following species in the British Museum have been examined:—*Hartigia linearis* (Schrank) ♂ and ♀; *H. niger* (Harris) ♂ and ♀; *H. nigrata* (Down.) ♀ (= *Pachycephus nigratus* Down. = *Janus nigratus*

(Dovn.) Gussakovskii); *H. sibiricola* (Jakovl.) ♀; *H. viator* (Smith) ♂ and ♀ (= *H. agilis* (Smith)); *H. trimaculata* (Say) ♂ and ♀.

Caenocephus Konow.

Caenocephus Konow, 1896, *Wien. ent. Ztg* 15: 151. (Genotype: *Caenocephus jakowleffi* Konow. Monobasic.)

Known from a very few examples of two species, *C. jakowleffi* Konow (E. Asia) and *C. aldrichii* Bradley (N.W. America). The genus is mainly characterised by purely negative characters, reduction of venation and antennae, and this gives some point to Klima's doubt whether the two species really belong to the same genus. Likewise Konow's association of a single female from Dalmatia with the male *C. jakowleffi* from Irkutsk seems very improbable. Gussakovskii and Klima have no right to change the spelling of this species to "*jakovlevi*."

Janus Stephens.

Janus Stephens, 1835, *Ill. Brit. Ent. Mand.* 7: 107. (Genotype: *Janus connectens* Stephens (by designation of Westwood 1840) = *Janus luteipes* (Lep.).)

Phylloecus Newman, 1838, *Entom. Mag.* 5: 485. (Genotype: *Phylloecus faunus* Newman. Monobasic.)

Ephippionotus O. Costa, 1860, *Fauna Regno Napoli*, Imen. 3, Cefidei: 11. (Genotype: *Ephippionotus luteiventris* O. Costa = *Janus compressus* (Fab.). Monobasic.)

Ries (1937) argues at some length about the identity of *Cephus femoratus* Curtis and *Janus connectens* Stephens. First he argues that *Cephus femoratus* has been misinterpreted and that the description does not refer to the species of *Janus* with which it is generally identified, because the structural figures, on Curtis's plate 301, of the claws, mandibles and antennae, obviously belong to a true *Cephus* and not a *Janus*. Unfortunately he has overlooked the fact that Curtis (1824: 1, footnote) makes it quite clear that these structural figures were never intended to represent parts of the *Cephus femoratus*, coloured on the same plate, but to *Cephus pygmaeus* (L.), the type of the genus *Cephus*. "The reader," he says, "will please to observe that, throughout the work, the dissections will be made from the insect established as the type of the genus, unless stated to the contrary; and the figures occurring in the descriptions will relate to the same figures in the plate." As on the top of p. 301 he gives "*Sirex pygmaeus* L." as type of the genus *Cephus*, the only mystery here is one of Ries's own weaving. The unwarranted assumption that these dissections belonged to *Cephus femoratus* led Ries to postulate the "undoubted" existence of a true *Cephus* in Britain with a general facies like that of the species now known as "*Janus femoratus* (Curtis)."

Quite apart from general facies, the coloured figure on p. 301 shows definite *Janus* characteristics (shown even clearer in the set of original drawings, at Tring, than in the reproduction); note the antennae and the long hind basitarsus, longer than the 3 following tarsal segments (as in Hartigini but not Cephini), the forward position of the front ocellus (as in *Janus* but not Cephini) and the form of the base of the anal cell in the fore-wing (which is peculiar to *Janus*). Finally Curtis says that the specimen was taken "off an oak"—the known foodplant of the species now called *Janus femoratus* (Curtis). If, as Ries says, the type label of *Cephus femoratus* Curtis is now affixed to a true *Cephus* in Curtis's collection (at the National Museum, Melbourne, Australia), then the specimen to which the label is now affixed cannot be the type of Curtis's species as it does not agree with the description.

The confusion over the identification of *Janus connectens* Stephens probably arose from the fact that it is a male specimen. For a long time it was not realised that male *Janus luteipes* (Lep.) lack the black femora characteristic of their respective females, but have, instead, red hind femora as in both sexes of *J. femoratus*. Gussakovskii (: 348) was unaware of this. A male with red hind femora was thus naturally dubbed "*J. femoratus*." In 1935 I had not met with *J. luteipes* in the field and had seen too little material of it to have any confidence about separating the males, so I was not prepared to offer any opinion on the identity of Stephens's type. In recent years I have found both species in the field in some abundance, and, once the males had been captured with their respective females and correlated with them in head sculpture, other differences became apparent. Hence my later personal communication, mentioned by Ries, to the effect that *Janus connectens* Stephens = *J. luteipes* (Lep.).

In British-caught material *J. luteipes* and *femoratus* can be separated thus :—

Janus luteipes (Lep.) (= *J. connectens* Steph.).

Hind femur black in ♀, but red in ♂. Head above with definite and dense punctures. Tegula black or brown, but pronotum edged with white behind. ♂ with yellow apical sternite and with 3 or more apical tergites marked with yellow. Attached to *Salix*, *Populus* and *Viburnum*.

Janus femoratus (Curtis).

Hind femur red in both sexes. Head shining to coriaceous above with very shallow ill-defined punctures. Tegula yellow, but pronotum not edged with white behind. ♂ with at most apical sternite and tergite brown. Attached to *Quercus*.

It is mentioned above that the hind tibia in some species of the genus may have but one pre-apical spine (e.g. *J. rufiventris* (Cresson) in N. America, and *J. kashivorus* (Yano & Sato) in Japan) and the hind-wing may lack an enclosed cubital cell (e.g. *J. piri* (Okamoto & Muramatsu) in Japan). Furthermore *J. kashivorus* has the 3rd and 4th antennal segments of equal length. For a note on *Janus nigratus* (Dovn.) Gussakovskii and *J. giganteus* Enderlein see under *Hartigia*; both these species were originally placed in *Janus* because they have two pre-apical tibial spines.

This genus shows a wider range of host-plants than the others, both within the species and among the species. Throughout its range the genus contains a number of economic pests, mostly of fruit trees.

Representatives in the British Museum of the following species of *Janus* have been examined :—*Janus abbreviatus* (Say) ♀; *J. compressus* (Fab.) ♂ and ♀; *J. femoratus* (Curtis) ♂ and ♀; *J. integer* (Norton) ♀; *J. luteipes* (Lep.) ♂ and ♀.

Janus malaisei sp. n.

Colour black with tergites 2-5 and base of 6, and sternites 2-6 fulvous; the following parts yellowish white: mouthparts (except for brown apices of mandibles), base of tegula, legs (except for the piceous bases of coxae, hind femur, and apical tarsal segment of all legs). Wings hyaline except for a small brown fleck, about 0.2 mm. in diameter in the middle of the 2nd apical cell of the fore-wing. Punctuation and pubescence: whole insect shining, with fine pale pubescence, but almost impunctate except for the feebly and finely punctured mesonotum and the hair follicles on the abdomen. Head: eyes a little higher than long (1.2:1.0); front ocellus about $\frac{1}{2}$ as far from an antennal socket as from the hind margin of the head; ant.-ant. shorter than ant.-tent. (1.0:1.3). Antenna 27-segmented,

with 3 longer than 4 (1.3 : 1.0) and 17 onwards broader than long. *Wings* normal, with radius of fore-wing obsolete just before it joins the stigma and directed to a point on the stigma at about $\frac{1}{4}$ from base of stigma. *Legs* with two pre-apical spines on hind tibia. *Abdomen* with saw-sheath slightly curved downwards, about $\frac{2}{3}$ as long as basal plate and set at about an angle of 45° to it; saw with normal truncated teeth characteristic of the genus. *Length* 9 mm. (without ovipositor); fore-wing 8 mm.; antenna 6 mm.

NORTH-EAST BURMA : Kambaiti, 7000 ft., 1 ♀, 16.v.1934, *R. Malaise* (Stockholm Museum).

This species appears to be related to *J. nigromaculatus* Sato (Japan), which is similarly coloured but has two dark flecks in the fore-wing of the female (in the 4th cubital and 3rd discoidal cells). The nearctic *J. bimaculatus* (Norton) is also very similarly coloured, but has also two flecks in the fore-wing (in the 4th cubital and 2nd apical cells).

Syrista Konow.

Syrista Konow, 1896, *Wien. ent. Ztg* 15 : 150. (Genotype : *Cephus parreysii* Spinola. Monobasic.)

Neosyrista Benson, 1935, *Ann. Mag. nat. Hist.* 15 (10) : 547 (syn. n.). (Genotype : *Neosyrista japonica* Benson (by original designation)—*Syrista similis* Mocsáry.)

Two species, very similar in general facies and both attached to *Rosa*, are represented in the British Museum and are probably the only described species belonging to this genus. *Syrista parreysii* (Spinola) is limited to the Mediterranean region eastwards to the Caucasus and is distinguished from its Japanese counterpart, *S. similis* Mocsáry, by the absence of the cross-vein to the anal cell in the fore-wing, by the head not being contracted behind the eyes and by its eye-shape (length to height 1.0 : 1.5 instead of 1.0 : 1.3). *S. speciosa* Mocsáry (China) would appear from its description to belong to *Cephalocephus* gen. n. (see below) or to another new genus, but certainly not to *Syrista*.

Cephalocephus gen. n.

(Description given in the key above.)

Cephalocephus xanthus sp. n.

Colour yellowish-white with the following parts brown to black : apices of mandibles, apices of antennae from about segment 17, space between ocelli, and between ocelli and antennal sockets, hind margin of head obscurely, front margin and medial line of pronotum, fore lobe of mesonotum and front $\frac{1}{2}$ of side lobes, medial line and hind margin of scutellum, metascutellum, front margin of mesopleura together with the edges of the pleural and sterno-pleural sutures, fore part of metasternum, base of 1st abdominal tergite, the medial dorsal part and more or less the base of tergites 2–8, also the bases of the sternites. *Punctuation and pubescence* : whole insect shining with fine clothing of pale hairs; almost impunctate except for the finely and feebly punctured mesonotum and the hair follicles on the abdomen. *Head* : eye more than $1\frac{1}{2}$ times as high as long (1.6 : 1.0); antenna with 32 segments none of which is broader than long. *Abdomen* with saw-sheath set at about angle of 45° to line of basal plate; saw missing in type. *Length* 14 mm.; fore-wing 12.5 mm.; antenna 8 mm.

NORTH-EAST BURMA : Kambaiti, 7000 ft., 1 ♀, 25.v.1934, *R. Malaise* (Stockholm Museum).

In addition to this new species it seems almost certain that *Syrista speciosa* Mocsáry (1901, *Ann. Mus. nat. Hung.* 2 : 496) from "Montes Mauson, Tongking," China, also belongs to this genus. The description, so far as it goes, bears out this theory and if this be a correct interpretation the two would appear to be

very closely similar, agreeing closely in colour and size. *S. speciosa* is apparently distinguished by having its antennae black, except at their apices.

Tribe **Pachycephini** trib. n.

Two genera, confined to the Mediterranean region and the Eurasian Steppes, are included here on the basis of similarity of general form of head, mandibles, antennae, apical sternites and genitalia of male and geographical range. Unfortunately nothing is known for certain about the host-plant relationships, though quite probably they are attached to Gramineae. Mavromoustakis, in a letter dated 17.iii.1945, tells me that his series of *Pachycephus smyrnensis* Stein was collected in the morning sunshine at flowers of *Papaver Rhoeas* L. growing in the wheat-fields and pastures of the plains of Cyprus, and that in the afternoon, when these flowers are closed, he has found adults inside them.

The present grouping cuts right across the previous system of Konow, who included *Pachycephus* in Macrocephides and *Characopygus* in Cephides on the basis of the proportional lengths of the 3rd to 4th antennal segments.

Key to Genera of Pachycephini.

1. Antenna 16-17 segmented; 3 longer than 4; flagellum not more than twice as long as the breadth of the head; ant.-ant. to ant.-tent. as 1:0.5. ♂ with 8th sternite unmodified and without apical fringe of setae. Head with genal carina on lateral hind margin of head not extending up to level of top of eyes and may be obsolete. 7 species. *Pachycephus* Stein.
- . Antenna 15-21 segmented; 3 not longer than 4; flagellum more than twice as long as breadth of head; ant.-ant. to ant.-tent. as 1:0.8. ♂ with 8th sternite short, depressed and with apical fringe of ribbon-like setae. Head with genal carina up to level of top of eyes (as in all other CEPHINAE). 3 species. *Characopygus* Konow.

Pachycephus Stein.

- Pachycephus* J. P. E. F. Stein, 1876, *Ent. Zig Stettin* 37: 60. (Genotype: *Pachycephus smyrnensis* Stein. Monobasic.)
Eversmannella Jakovlev, 1892, *Hor. Soc. ent. ross.* 26: 15. (Genotype: *Cephus cruentatus* Eversmann. Monobasic.)
Spatulocephus Pic, 1916, *Échange* 32: 24. (Genotype: *Spatulocephus sanctus* Pic. Monobasic.)

P. cruentatus (Eversmann), the type of *Eversmannella*, differs from the other *Pachycephus* spp. in the British Museum in lacking a carina on the hind margin of the head, a character which among CEPHIDAE it shares only with *Athetocephus*, but this character does not alone justify the recognition of *Eversmannella* as a distinct genus.

Representatives in the British Museum of the following species have been examined: *Pachycephus smyrnensis* Stein, ♂ and ♀; *P. sp.?* *brevis* Ghigi, ♂ and ♀; *P. cruentatus* (Eversmann), ♀.

Characopygus Konow.

- Characopygus* Konow, 1899, *Ent. Nachr.* 25: 73. (Genotype: *Characopygus moricei* Konow. Monobasic.)

Representatives in the British Museum of the following species have been examined: *Characopygus moricei* Konow, ♀; *C. scythicus* Dvñ., ♂.

Tribe Cephini.

- Cephides Konow, 1899, *Ent. Nachr.* 25: 74.
 CEPHINAE Enslin, 1914, *Ins. Mitteleur.* 3: 195.
 Cephini Enslin, 1918, *Tenthred. Mitteleur.* : 684.

This section of the CEPHIDAE, associated entirely with the Gramineae as host-plants, is concentrated in the Mediterranean region and Eurasian steppes into S.W. Asia, but all three genera have a holarctic distribution and are represented in N. America each by a single native species. They probably represent the most recent development in the family and are thus characterised by numerous small segregations of species. The naming of these small segregations as ill-defined genera has been carried on to such an extent that all idea of classifying the group has been lost in a plethora of trivial genera. To deal with this group has been a most difficult task. Admittedly, on a purely morphological basis, many genera might be recognised, but, without the help of differences in biology, morphological differences can be very misleading in interpreting natural genera. A special structure may, for example, be a characteristic development in a natural group and yet be absent in certain members of the group. The study of genetics supports this contention. A characteristic of *Trachelus*, for example, is the tendency of the males to develop a deep pit, bearing modified setae, on one or more of the apical sternites, but *Microcephus judaicus* (Konow) has not developed these pits, though on other characters it would appear to belong to *Trachelus*.

Looking for larger correlations of characters, there are three groups with numerous correlated characters and these are best regarded as the genera. All the monotypical genera have therefore been ruthlessly lumped with the most nearly related larger genera; if the recognition of these smaller groups as distinct genera becomes desirable later, on biological or other grounds, there will be names available in plenty.

In this synthesis I do not go so far as Ries, who places American representatives of each of the three groups into a single genus, *Cephus*, though he does admit that they represent three segregations which he groups into two sub-genera—not genera—because he could find no reliable external characters for separating them. The finding of good external characters has rather changed the picture and our views do not probably really differ much, except in terminology; I do not use named sub-genera, holding that the sub-specific concept is a very useful one and that the potential trinomial name is quite long enough. The resulting classification is, however, much the same because I put a tribal name, Cephini, round these three genera.

In the synthesis I have been much troubled by the anomalous species: *Microcephus judaicus* (Konw.), *Haplocephus aureus* Benson, and *Cephus nigripennis* Takeuchi. Of the former I have seen only a single pair, of which the female is damaged; the male has excessively long tarsi; on the greatest number of characters it presumably belongs to *Trachelus*, but, as mentioned above, the male has no apical sternal pits. The other two, of which I have only seen single males, I provisionally associate with *Calameuta*, though they have better-developed apical sternal spines than is characteristic of that genus.

Key to Genera of Cephini.

1. Less slender insects with ant.-ant.: ant.-tent. as 1.0:1.0 to 1.4 (fig. 1).

Distance between eyes in front always greater than longest dimension of an eye. Pronotum generally transverse. ♀ with cerci less than $\frac{1}{2}$ (1.0:2.4 to 4.5) as long as lower margin of saw-sheath and oblong plate less than twice (1.1 to 1.7:1) as long as lower length of saw-sheath (fig. 32). ♂ usually with a conspicuous fringe of flattened setae at apex of 8th sternite, or with at least 7th and 8th sternites each with a cavity bearing thickened modified setae (figs. 37 and 38). Apex of labial palp much broader than apex of maxillary palp 2.

- . Slenderer insects with ant.-ant. : ant.-tent. as 1.0 : 1.5 to 2.0 (fig. 2). Distance between eyes in front usually less than longest dimension of eye. Pronotum long (length of side usually longer than narrowest breadth in dorsal view). ♀ cerci at least $\frac{1}{2}$ as long as lower length of saw-sheath and oblong plate about twice as long as saw-sheath (fig. 33). ♂ 8th sternite may have a patch of simple hairs or a reduced apical fringe, but the modified flattened setae are obsolete or much reduced. Apex of labial palp generally scarcely broader than apex of maxillary palp. 21 species. *Calameuta* Konow.
2. Ant.-ant. : ant.-tent. as 1.0 : 1.0. ♀ with saw-sheath not broadening behind (fig. 35) (in dorsal aspect not broader at apex than apex of hind tibia). ♂ 8th sternite bearing only a patch and an apical fringe of modified flattened setae (fig. 38). Hind tibia with 1-2 pre-apical spines. 25 species. *Cephus* Latreille.
- . Ant.-ant. : ant.-tent. as about 1.0 : 1.2. ♀ saw-sheath broadening behind (fig. 34) (in dorsal aspect with greatest breadth greater than apex of tibia). ♂ may have 2 or 3 apical sternites each with a deep concavity bearing modified setae (fig. 37). 8 species. *Trachelus* Jurine.

Cephus Latreille.

- Cephus* Latreille, 1802, *Sonnini's Buffon, Ins.* 3 : 303. (Genotype: *Sirex pygmaeus* L. = *Cephus pygmaeus* (L.). By subsequent designation of Latreille 1810.)
- ? *Perinistilus* Ghigi, 1904, *Annuario Mus. Napoli.* (n.s.) 1 : 26. (Genotype: *Cephus politissimus* Costa. Monobasic.)
- ? *Pseudocephus* Dovnar-Zapolskii, 1931, *Annu. Mus. zool. Acad. Leningrad* 32 : 47. (Genotype *Cephus pulcher* Tisch. Original designation.)
- ? *Peronistilomorphus* Pic, 1916, *Échange* 33 : 381. (Genotype: *Peronistilomorphus berytensis* Pic. Monobasic.)

Holarctic, concentrated in Eurasian steppes. By the new definition of *Calameuta* a group of species formally placed in *Cephus* are now transferred thereto. These species include the seven separated off in the first part of Gussakovskii's key (1935 : 357-8) on the basis of their thin antennae with a definite apical club, as well as *Cephus sachalinensis* Takeuchi (Japan) and *C. clavatus* (Norton) (N. America). I have no specimen of the genotypes of the genera *Perinistilus*, *Pseudocephus* or *Peronistilomorphus*, or even of any other species that have been included in them, and do not know for certain if they are correctly placed here. The first two were mainly separated from *Cephus* on the basis of their lacking one of the two pre-apical spines on the hind tibia, a character now known not to be significant here. An examination of the species included in these genera may show that some of them belong properly to *Calameuta*.

Representatives in the British Museum of the following species have been examined: *Cephus brachycercus* Thomson, ♀; *C. cinctus* Norton, ♂ and ♀; *C. cultus* Eversm., ♂ and ♀; *C. fumipennis* Eversm., ♂; *C. hyalinatus* Konow, ♀; *C. lateralis* Konow, ♀; *C. nigrinus* Thomson, ♂ and ♀; *C. pygmaeus* (L.), ♂ and ♀; *C. runcator* Konow, ♂; *C. ? tanaiticus* Down., ♀.

Trachelus Jurine

- Trachelus* Jurine, 1807, *N. Méth. Class. Hyménopt.* 72. (Genotype: *Sirex tabida* Fabr. (Monobasic) = *Trachelus tabidus* (Fabr.).)
- Ateuchopus* Konow, 1896, *Wien. ent. Ztg* 15 : 151, 174. syn. n. (Genotype: *Ateuchopus armenius* Konow. Subsequent designation of Rohwer 1911.)
- Eumetabolus* W. A. Schulz, 1906, *Spolia hym.* : 211. (Genotype: *Sirex troglodyta* F. Subsequent designation of Rohwer 1911.)
- Trachelastatus* Morice & Durrant, 1915, *Trans. ent. Soc. Lond.* 1914 : 383. (nom. n. pro *Trachelus*.)
- Neateuchopus* Benson, 1935, *Ann. Mag. nat. Hist.* 16 (10) : 543. syn. n. (Genotype: *Neateuchopus tigris* Benson. Original designation.)
- Microcephus* Benson, 1935, *Ann. Mag. nat. Hist.* 16 (10) : 545. syn. n. (Genotype: *Monoplopus judaicus* Konow. Original designation.)

I group together into one genus the species previously included in *Trachelus* and *Eumetabolus*, largely on the similarity in the form of their female saw-sheaths and their male sternites. There is considerable variation here in the form of the antennal thickening, supraclypeal area, proportions of the leg segments, etc.; each of these characters, if used in an attempted further dividing, would give rise to different segregations of species! I also include here *Ateuchopus*, which lacks pre-apical spines to its hind tibia and which in the male has three instead of two modified sternal segments. Also, with some misgivings, I include the superficially very similar *Microcephus judaicus* (Konw.) (= *Monoplopus judaicus* Konw.); this species, in its exceptionally long tarsi, especially the penultimate segment of the hind tarsus (which is almost as long as the last segment), differs from all other Cephids I have seen; its saw-sheath is, however, broadened as in other *Trachelus* spp. and its supraclypeal area is of similar proportions, but the male has unmodified sternites.

The genus as reconstituted contains the following described species. Those marked with an asterisk * are species of which I have seen no representative and which are not represented in the British Museum collections. The name in brackets refers to the genus in which they were included in Klima's recent catalogue: **Trachelus armenius* (Konow) (*Ateuchopus*); *T. flavicornis* (Lucas) (*Eumetabolus*) ♂ and ♀; *T. judaicus* (Konow) (*Microcephus*) ♂ and ♀; *T. libanensis* (André) (*Ateuchopus*) ♂ and ♀; *T. tabidus* (Fabr.) (*Trachelus*) ♂ and ♀; * *T. tenuicornis* (Konw.) (*Eumetabolus*); *T. tigris* (Benson) (*Neateuchopus*) ♀ (in Konow's Coll.); *T. troglodyta* (Fabr.) (*Eumetabolus*) ♂ and ♀.

Calameuta Konow.

Calameuta Konow, *Wien. ent. Ztg* 15: 151. (Genotype: *Cephus filiformis* Eversmann. Subsequent designation of Rohwer 1911.)

Monoplopus Konow, *Wien. ent. Ztg* 15: 151. syn. n. (Genotype: *Tenthredo saltum* (L.) Fabr. nec L. (Subsequent designation of Rohwer 1911) = *Ichneumon pygmaeus* Poda.)

Haplocephus Benson, 1935, *Ann. Mag. nat. Hist.* 16 (10): 544. syn. n. (Genotype: *Haplocephus aureus* Benson. Original designation.)

In the present arrangement rather radical changes are suggested in the conception of this genus, which is broadened to include *Monoplopus* and a section of *Cephus*, and which yet now, as not before, contains species showing a remarkably uniform correlation of character. *Haplocephus aureus* Benson presents two unique features in the genus with its entirely simple claws and its patches of modified setae on two apical male sternites. As, however, the description was based on a single male specimen it seems undesirable to maintain a monotypical genus for it. *C. haemorrhoidalis* (Fab.) differs from all other CEPHIDAE known to me in having a long 5th segment of the maxillary palp almost as long as the 6th segment.

The present conception of *Calameuta* now embraces the following described species; those species marked with an asterisk * are those of which I have seen no representatives and which are not represented in the British Museum; the name in brackets refers to the genus under which the name appeared in Klima's recent catalogue: * *Calameuta amurensis* Guss. (*Calameuta*); * ? *C. apicornis* (Pic) (*Monoplopus*); * *C. antigae* Konow (*Calameuta*); *C. aureus* (Benson) (*Haplocephus*) ♂; *C. clavatus* (Norton) (*Calameuta*) (= *Cephus clavatus* (Norton) Ries 1937) ♂; * *C. diversipes* (Ghigi) (*Cephus*); *C. filiformis* (Eversm.) (*Calameuta*) ♂ and ♀; *C. filum* (Guss.) (*Cephus*) ♂ and ♀; *C. gaullei* (Konw.) (*Cephus*) ♀; * *C. gracilicornis* (Konw.) (*Cephus*); *C. grombcezkii* (Jakovl.) (*Calameuta*) ♀; *C. haemorrhoidalis* (Fabr.) (*Cephus*) ♂ and ♀; *C. idolon* (Rossi) (*Monoplopus*) ♀; *C. infernalis* Dovn. (*Calameuta*) ♀; * *C. moreanus* (Pic)

(*Monoplopus*); *C. nigripennis* (Takeuchi) (*Eumetabolus*) (= *Cephus nigripennis* (Tak.) Tak. 1928) ♂; *C. pallipes* (Klug) (*Cephus*) ♂ and ♀; * *C. pravei* (Dovn.) (*Cephus*); *C. pygmaeus* (Poda) (*Monoplopus*) ♂ and ♀; * *C. sachalinensis* (Tak.) (*Cephus sachalinensis* Takeuchi 1938); * *C. turanicus* Dovn. (*Calameuta*).

Subfamily ATHETOCEPHINAE.

ATHETOCEPHINAE Benson, 1935, *Ann. Mag. nat. Hist.* **16** (10) : 541.

One genus.

Athetocephus Benson.

Athetocephus Benson, 1935, *Ann. Mag. nat. Hist.* **16** (10) : 541. (Genotype : *Athetocephus madecassus* Benson. Original designation.)

Large yellow species, 10–15 mm. long. Antenna 20–28 segmented. Hind tibia without pre-apical tibial spines. ♂ with 8th sternite deeply impressed each side of a medial carina and with apical fringe of ribbon-like setae. Eye about $1\frac{1}{4}$ times higher than long.

Two species : *Athetocephus madecassus* Benson and *A. maculatus* Benson; confined to Madagascar.

Summary of the Host-plants of CEPHIDAE.

CEPHINAE.

Lartigiini : Rosaceae and other arborescent Dicotyledones.

Hartigia : herbaceous or shrubby Rosaceae.

H. cressoni (Kirby) : *Rosa* and *Rubus* (N. America).

H. linearis (Schrank) : *Agrimonia* *Eupatoria* L., *Filipendula* *Ulmaria* (L.) Maxim., *Sanguisorba officinalis* L. (Europe).

H. nigra (Harris) : *Rubus* (Europe).

H. trimaculata (Say) : *Rosa* and *Rubus* (N. America).

Caenocephus (unknown) (E. Asia and N.W. America).

Janus : woody Rosaceae (*Pyrus* and *Malus*), Fagaceae (*Quercus*), Salicaceae (*Populus* and *Salix*), Caprifoliaceae (*Viburnum*) and Grossulariaceae (*Ribes*).

J. abbreviatus (Say) : *Populus* and *Salix* (N. America).

J. compressus (F.) : *Pyrus* and *Malus* (Europe).

J. femoratus (Curtis) : *Quercus* (Europe).

J. integer (Norton) : *Ribes* (N. America).

J. japonicus Sato : *Viburnum* (Japan).

J. kashivorus Yano & Sato : *Quercus* (Japan).

J. luteipes (Lep.) : *Populus*, *Salix* and *Viburnum* (Europe).

J. piri Okamoto & Muramatsu : *Pyrus communis* L. (Korea).

Syrista : *Rosa*.

S. parreysii (Spin.) : *Rosa* (Mediterranean).

S. similis Mocs. : *Rosa* (E. Asia).

Cephalocephus : (unknown) (Tropical Asia).

Pachycephini : *Pachycephus* and *Characopygus* (unknown, but quite probably associated with Gramineae) (Mediterranean).

Cephini : Gramineae; most of them actual or potential pests of forage- or grain-grasses, as, those that have been studied, prove to have a wide host-range.

Calameuta filiformis (Evers.) : *Agropyron repens* (L.) Beauv., *Arrhenatherum elatius* (L.) J. & C. Presl, *Calamagrostis epigejos* (L.) Roth. and *Phragmites communis* Trin. (Europe).

C. nigripennis Tak. : *Agropyron* (E. Asia).

- Cephus cinctus* Norton : *Agropyron*, *Bromus*, *Calamagrostis*, *Deschampsia*,
Elymus, *Festuca*, *Hordeum*, *Phleum*, *Secale* and *Triticum* (N. America).
C. cultratus Evers. : *Phleum pratense* L. (Europe).
C. infuscatus Thoms. : *Phalaris arundinacea* L. (Europe).
C. nigrinus Thoms. : *Poa pratensis* L. (Europe).
C. pygmaeus (L.) : *Agropyron*, *Avena*, *Bromus*, *Hordeum*, *Phleum*, *Secale*
and *Triticum* (Europe and Mediterranean, and introduced into N.
America).
Trachelus flavicornis (Lucas) : *Triticum* (Pest on wheat in Batna district
of Algeria in 1931; specimens sent to Brit. Mus. by M. Delassus of La
Défense des Cultures) (Mediterranean).
T. tabidus (F.) : *Hordeum*, *Secale* and *Triticum* (Europe and Mediterranean,
and introduced into N. America).
T. troglodyta (F.) : *Secale cereale* L. (Pest on rye in C. Russia) (Europe).
ATHETOCEPHINAE : (unknown) (Madagascar).

List of British CEPHIDÆ.

- Hartigia nigra* (Harris).
Hartigia linearis (Schrank).
Janus femoratus (Curtis).
Janus luteipes (Lep.).
Calameuta filiformis (Eversmann).
Calameuta pallipes (Klug).
Cephus cultratus Eversmann.
Cephus nigrinus Thomson.
Cephus pygmaeus (L.).
Trachelus tabidus (F.).
Trachelus troglodyta (F.).

Phylogeny of CEPHIDÆ.

Ries maintains that *Janus* is the most primitive Cephid, largely on the basis of its threadlike antennae and its claws. It certainly has a rather wider food-plant range than other known Macrocephini, both within the species and among the species.

Correlated with any primitive characters it has, there are numerous highly specialised and unique features, as have been listed above. It has already been stressed above that the characteristics of genera and larger groups should be looked for in correlations of characters and not in individual characters. Without a very complete fossil record it is not going to be easy to decide which generic correlations were first established. The only known Cephid fossils are of forest insects, one or two from Baltic Oligocene amber and one from the Miocene of Florissant Colorado. These are Hartigiini related to *Janus*, but no significance can be attached to such sparse and such recent records of forest insects, when one knows Cephids are concentrated in the steppes.

The description "primitive" applied to living animals is used in more than one sense. Many of the growing points of evolution are in some ways generalised organisms, retaining of necessity a primitive adaptability. Primitive is also used to describe senile forms, archaic in some characters, highly adapted in others, but no longer adaptable. Most "phylogenetic" study today is a fruitless search for living fossils. In groups in which scarcely any fossils are known there are scarcely any by which to identify them. On a purely morphological basis living organisms generally present one with a mosaic of correlated

primitive and highly specialised characters. The best one can hope to do is to build up an imaginary archetype of primitive characters and pretend that the common ancestors of the group passed through some such stage in its evolution. But how can one recognise the primitive characters and separate them from secondary simplifications when there must be no actual records for comparison? Morphology is not enough. Just as one has a dynamic approach to systematics, so there must be to phylogeny. What did the Cephid archetype feed on and where did it live? From the distribution table it will be seen that the Cephini and Pachycephini are predominately steppe insects and the others predominately forest insects.

The predominant food-plants are Gramineae on the one hand and on the other arborescent Dicotyledones, especially Rosaceae with their well-known tendency to produce shrubby as well as herbaceous forms. The main centres today seem to be where the temperate forests merge into the Eurasian steppes. Just where one would expect their known food-plants to have developed. I think it is safe to assume that the very specialised plant associations of Cephids (and other sawflies) developed after their morphological segregation into the families now known and that the Cephid archetype was a general pith feeder. This habit of internal feeding has enabled Cephids to survive the direct effects of summer drought under steppe conditions.

Table to show world-distribution of CEPHIDAE.

The presence of “?” means that the species concerned may not be correctly placed generically. The species in brackets under N. America are established introduced aliens from Europe.

	No. of species	Britain	W. Eurasian Forests	Mediterranean and Eurasian Steppes	E. Eurasian temperate Forests	Tropical Asia	Madagascar	N. America
<i>Hartigia</i>	(12 + ? 1)	2	2	5	4	(? 1)	—	3
<i>Janus</i>	(13)	2	2	1	5	1	—	4
<i>Caenocephus</i>	(2)	—	—	—	1	—	—	1
<i>Syricta</i>	(2)	—	—	1	1	—	—	—
<i>Cephalocephus</i>	(1 + ? 1)	—	—	—	—	1 (+ ? 1)	—	—
<i>Pachycephus</i>	(7)	—	—	7	—	—	—	—
<i>Characopygus</i>	(3)	—	—	3	—	—	—	—
<i>Calameuta</i>	(21)	2	2	16	3	—	—	1
<i>Cephus</i>	(25)	3	5	17	2	—	—	1 (+ 1)
<i>Trachelus</i>	(8)	2	2	7	—	—	—	(1)
<i>Athetocephus</i>	(2)	—	—	—	—	—	2	—
Total	(98)	11	13	57	18	4	2	10 (+ 2)

REFERENCES.

- BENSON, R. B., 1935, On the Genera of the CEPHIDAE, and the Erection of a new Family SYNTEXIDAE (Hymenoptera Symphyta). *Ann. Mag. nat. Hist.* 16 (10): 535-53.
- CURTIS, J., 1824 and 1830, *British Entomology* 1: 1 and 7: 301.
- ENSLIN, E., 1918, Die Tenthredinoidea Mitteleuropas, 7. *Dtsch. ent. Z., Beih.* 1917: 683-703.
- GUSSAKOVSKII, V. V., 1935, *Faune de l'URSS* (n.s.) No. 1 *Insectes Hyménoptères*. T. 11, vol. 1. *Chalastogaster*, Pt. 1.
- KLIMA, A., 1937, in Hedicke's *Hymenopterorum Catalogus*, 2, CEPHIDAE-SYNTEXIDAE.

- KONOW, F. W., 1904-5, *Syst. Zusammenst. Chalastog.*, *Cephini*: 228-77.
- RIES, D. T., 1937, A Revision of the nearctic CEPHIDAE (Hymenoptera). *Trans. Amer. ent. Soc.* **63**: 259-324.
- ROHWER, S. A., 1911, The genotypes of the sawflies and woodwasps. *U.S. Dept. Agric., Tech. Series*, **20**: 69-109.
- , 1915, A remarkable new Genus of CEPHIDAE. *Proc. ent. Soc. Washington* **17**: 114-17.
- ROSS, H. H., 1937, A Generic Classification of the Nearctic Sawflies (Hymenoptera, Symphyta). *Illinois Biol. Mon.* **15** (2).
- TAKEUCHI, K., 1938, A Systematic Study of the Suborder Symphyta (Hymenoptera) of the Japanese Empire (1). *Tenthredo, Acta Entomologica* **2** (2): 195-203.

24 MAY 1946

Vol. 96. Part 7. Pp. 109-124, 12 figs.

15th May, 1946.

Eu. 344

THE
TRANSACTIONS
OF THE
ROYAL
ENTOMOLOGICAL SOCIETY
OF
LONDON

World List abbreviation: *Trans. R. ent. Soc. Lond.*

CONTENTS

PAGE

- X SOMEREN, E. C. C. van. Ethiopian CULICIDAE:
notes and descriptions of some new species and
hitherto unknown larvae and pupae (Diptera) . 109-124, 12 figs. ✓

LONDON:

PUBLISHED BY THE SOCIETY AND
SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 4s. 6d.

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Founded, 1833. Incorporated by Royal Charter, 1885.

PATRON—HIS MAJESTY THE KING.

OFFICERS and COUNCIL for the SESSION, 1946–1947.

PROF. G. D. HALE CARPENTER, M.B.E., D.M., *President*.

W. J. HALL, D.Sc.

C. B. WILLIAMS, M.A., D.Sc. } *Vice-Presidents*.

H. B. WILLIAMS, LL.D.

A. WELT, *Treasurer*.

N. D. RILEY, *Secretary*.

Other Members of Council.

C. H. ANDREWES, F.R.S.

J. W. EVANS, M.A., D.Sc.

G. FOX-WILSON, N.D.H.

R. M. GREENSLADE.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

CAPT. R. A. JACKSON, R.N.

MISS C. E. LONGFIELD.

SIR GUY A. K. MARSHALL, K.C.M.G.,

D.Sc., F.R.S.

G. E. J. NIXON, B.A.

J. F. PERKINS, B.Sc.

F. J. GRIFFIN, A.L.A., *Registrar*.

Finance and House Committee.

G. FOX-WILSON, N.D.H. (*Chairman*).

J. W. EVANS, M.A., D.Sc.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

W. RAIT-SMITH.

O. W. RICHARDS, M.A., D.Sc.

Publication and Library Committee.

W. J. HALL, D.Sc. (*Chairman*).

H. E. HINTON, B.Sc., Ph.D.

B. M. HOBBS, M.A., D.Phil.

J. F. PERKINS, B.Sc.

J. SMART, B.Sc., Ph.D.

W. H. THORPE, M.A., Sc.D.

Committee on Generic Nomenclature.

FRANCIS HEMMING, C.M.G., C.B.E. (*Chairman*).

W. A. F. BALFOUR-BROWNE, F.R.S.E.

K. G. BLAIR, D.Sc.

O. W. RICHARDS, M.A., D.Sc.

N. D. RILEY (*Secretary*).

Committee for the Protection of British Insects.

H. M. EDELSTEN, O.B.E. (*Chairman*).

R. B. BENSON, M.A.

E. A. COCKAYNE, M.A., M.D., F.R.C.P.

CAPT. R. A. JACKSON, R.N.

COL. F. A. LABOUCHERE.

A. M. MASSEE, D.Sc.

THE HON. MIRIAM ROTHSCHILD.

W. H. THORPE, M.A., Sc.D.

N. D. RILEY (*Secretary*).

The Executive Officers of the Society are *ex-officio* members of all Committees.

DELEGATES OF THE SOCIETY TO :

1. British National Committee for Biology (Royal Society).

Mr. Francis Hemming, C.M.G., C.B.E., appointed 1945.

Dr. V. B. Wigglesworth, M.A., B.Ch., M.D., F.R.S., appointed 1943.

2. Local Committee of Management of Wicken Fen.

Mr. H. M. Edelsten, O.B.E. [nominated by Committee for the Protection of British Insects].

3. National Trust for Places of Historic Interest or Natural Beauty.

Mr. H. M. Edelsten, O.B.E., appointed 1944.

4. New Forest Association.

Mr. W. Fassnidge, appointed 1934.

5. New Forest Joint Committee.

Mr. W. Fassnidge, appointed 1939. Dr. F. J. Killington, D.Sc., A.L.S., appointed 1939.

6. Royal Meteorological Society. Phenological Committee.

Dr. C. B. Williams, M.A., D.Sc., appointed 1937.

7. Biology War Committee.

Prof. P. A. Buxton, M.A., F.R.S., appointed 1941.

8. Council for the Promotion of Field Studies.

Dr. W. H. Thorpe, M.A., Sc.D., appointed 1944.

9. Joint Bioclimatic Committee.

Dr. B. P. Uvarov, C.M.G., D.Sc., appointed 1945.

Dr. C. B. Williams, M.A., D.Sc., appointed 1945.

ETHIOPIAN CULICIDAE: NOTES AND DESCRIPTIONS OF SOME
NEW SPECIES AND HITHERTO UNKNOWN LARVAE AND PUPAE
(DIPTERA)

By E. C. C. van SOMEREN.

(Section of Medical Entomology, Medical Research Laboratory, Nairobi, Kenya.)

Manuscript received 8th March, 1945.

(Read 2nd May, 1945).

WITH 12 TEXT-FIGURES.

Aedes (Stegomyia) fraseri Edwards, 1912 (fig. 1).

THE larva of this species is very similar to that of *A. (S.) apicoargenteus* Theobald, but may be distinguished by the presence of stellate setae on the thorax and the comb spines which have a coarse basal fringe of denticles which reaches to near the apex of the spine. Colour grey with a dark brown head and siphon, the apical fourth of the siphon pale. Length about 8 mm. Head about as long as broad. Antenna short, about one-third the length of the head, cylindrical, and smooth; tuft a minute seta at three-quarters. Setae A, B, and C single, A sometimes bifid; *d* with 6-8 branches, small, and set well forward and inside C; *e* and *f* single. Mentum triangular with 8-10 teeth on either side of the central tooth, the basal 1-2 wider spaced and smaller. Thorax with medium-sized curved spines at the base of the meso- and metathoracic pleural tufts. Stellate seta present but inconspicuous. Abdomen. Comb a rather neat row of 10-14, usually 12, sharp-pointed spines, each with a wide basal fringe of fine denticles which reaches to near the apex. Siphon heavily chitinated on the basal three-quarters, apical quarter light. Index 1½-2. Pecten reaches to two-fifths and is an even row of 10-20 close set, fairly long, narrow, sharp-pointed spines each with 2-3 small basal denticles. Subventral tuft placed at a half, with 2-4 branches which are finely plumose under the high powers of the microscope and about the length of the diameter of the siphon at point of attachment. Saddle chitinated but incomplete. Lower caudal seta single, upper with 2 branches. Lateral seta single, finely plumose under the high powers of the microscope and about twice the length of the saddle. Gills rather variable, lanceolate, but sometimes sausage-shaped, subequal with the upper pair 2-3 times the length of the saddle, most often twice the length of the saddle. Ventral brush composed of 4 pairs of bifid setae.

Breeding Places. Common in tree holes and small holes in granite boulders in dense forest.

Collected from Kaimosi Forest, North Kavirondo, Kenya, by Dr. P. C. C. Garnham, Mr. J. O. Harper and Mr. R. B. Highton, Medical Department, Kenya.

Described from 10 whole larvae and 18 larval pelts. The adults were identified by dissections of the male terminalia and with the description in Edwards (1941).

The paedotypes will be deposited in the British Museum (Natural History).

TRANS. R. ENT. SOC. LOND. 96. PART 7. (MAY 1946.)

H

The Adults of *A. fraseri* Edwards and *A. apicoargenteus* Theobald.

The adults of *A. fraseri* and *apicoargenteus* from Kaimosi and Kakamega, North Kavirondo, Kenya, agree fairly well with Edwards' (1941) description and the *fraseri* seem to be fairly constant in ornamentation, except for the lateral white spots on the thorax which vary in size, especially in the females. The males have moderately large white lateral spots on the thorax nearly reaching the scutal angle, while the lateral white patches on the female vary from very small and sometimes elongated spots, to fairly large spots, usually slightly larger than those of *apicoargenteus* and more pointed behind but not quite so large as those seen in male *fraseri*.

A. apicoargenteus vary slightly from Edwards' (1941) description as follows : The white area on the posterior surface of the hind femur is, in the Kakamega specimens, much more extensive, almost half the basal area being white.

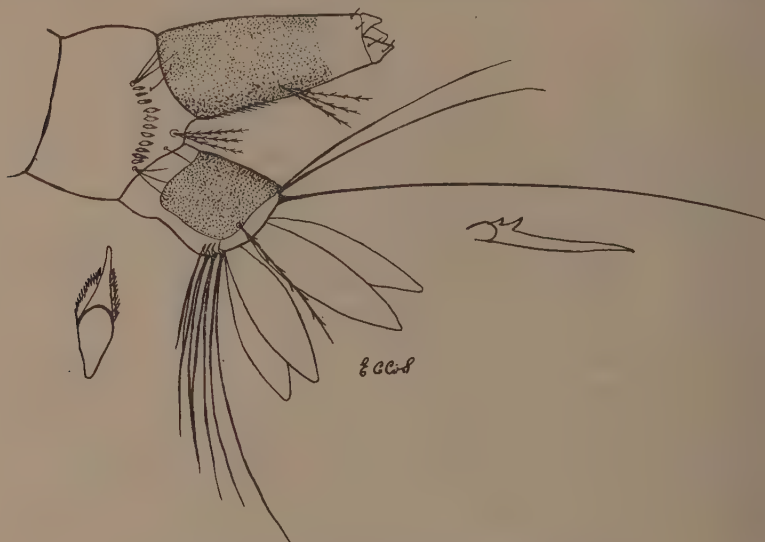


FIG. 1.—Larva of *Aedes (Stegomyia) fraseri* Edwards.

Occasionally there are white scales round the bare space in front of the scutellum and other specimens have white scales on the lateral lobes of the scutellum. Abdominal tergite IV very often has a silvery band. The posterior median white line on the thorax is very often continued forward to half-way between the lateral white patches. A few specimens collected at Bwamba, Toro District, Uganda, show a considerable variation in the amount of white on the posterior surface of the hind femur. One specimen has the posterior surface all black while the rest are white on the basal one-third to one-half.

It will be noticed from the above that couplet 14 of Edwards' key (1941) breaks down as the amount of white on the posterior surface of the hind femur of *apicoargenteus* is variable, thus necessitating a change in the key, as indicated in the notes at the end of this paper (p. 122).

A. fraseri can be easily distinguished from *apicoargenteus* by the leg markings, which are metallic in *apicoargenteus* and pure snow-white in *fraseri*.

***Aedes (Stegomyia) keniensis* sp. n. (fig. 2).**

This species is very similar to *Aedes deboeri* and *masseyi*. Although the thoracic markings and the male terminalia agree with *A. deboeri*, it differs from that species by having no white basal stripe on the hind tibia below; in this respect it agrees with *A. masseyi*, but differs in having a narrow white ring on the third hind tarsal segment and white scales bordering the bare space in front of the scutellum.

Edwards (1941: 146), under variation, mentions two female specimens from Nairobi (van Someren leg., 1924). These are probably referable to this new species, which is here described because differences seem to be constant, and the known distribution is within that of *deboeri*. It is quite possible that

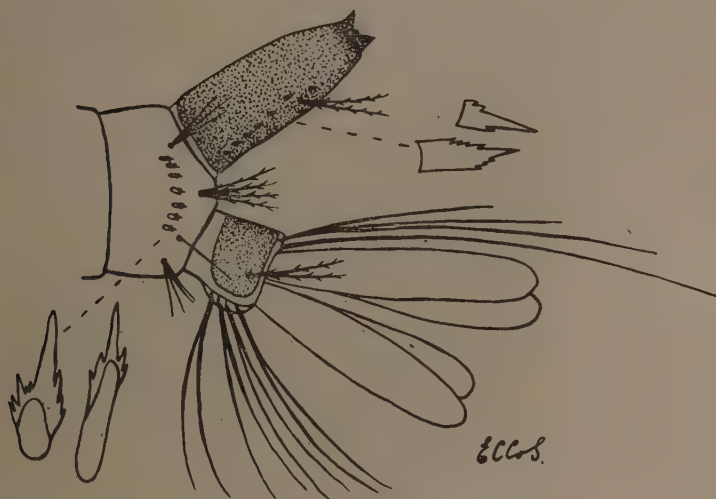


FIG. 2.—Larva of *Aedes (Stegomyia) keniensis* sp. n.

when the male and larvae of *masseyi* have been discovered, *keniensis* may prove to be a race of that species.

♀. *Head*. Ground colour black, with 2 silvery median white lines separated by a narrow black one; silvery white scales round the eye margins meeting small silvery white lateral patches. Erect scales on nape black. Palpi broadly white tipped. Tori with silvery white scales. Clypeus bare. Proboscis black. *Thorax* black with silvery white markings. Two moderately large pear-shaped silvery white patches, rather pointed behind, on either side anteriorly and reaching margin at scutal angle; two lateral white lines running from the scutellum to, but not quite reaching, the posterior points of the lateral patches; a white spot in the middle of the front margin consisting of broad or narrow scales and a continuous median yellowish line running back from it, forking in front of the scutellum and forming a narrow white border to the bare space in front of the scutellum; the white supra-alar areas small. All scutellar scales broad flat and white. *Abdomen* black with white markings. Tergites 3-6 with broad silvery white bands, 2 usually with a median basal silvery spot but sometimes with a silvery band or without markings, 7 with a small median basal silvery spot; basal white spots on tergites 1-7 large. Sternites with broad

basal silvery white bands. *Legs.* Fore and mid femora black, except at the base beneath; middle femora with a small white spot at tip above; anterior surfaces of hind femora white on a little more than the basal half, ending in a point distally, posterior surfaces white on a little less than the basal half, the black of the apex continued farther towards the base dorsally, but the basal one-quarter to one-third white all round, a small white spot at the tip above. Fore tibiae with a narrow white ring at the base; mid and hind tibiae all black. Fore and mid tarsi with a narrow white ring at the base of the first 2 segments only; first 3 segments of hind tarsi with basal white rings, that on the third very narrow, fourth all white, fifth all black.

♂. Ornamentations essentially the same as the female. *Head* with larger lateral white patches. Palpi with only one white band on the shaft, the more proximal one being absent and only represented by a small or large patch of white scales above. *Thorax* with the small white spots in the middle of the front margin usually composed of broad scales. *Abdomen.* Tergite 2 sometimes without a white band or spot; 8 with 2 dorsal lateral silvery spots. *Legs.* Hind tibia occasionally with a few whitish scales at the base below. *Terminalia* resembles that of *A. deboeri*; the basal plaque having 3 but sometimes 4 spines on its inner border, all more or less the same length; lobes of tergites with 8 long hairs.

Larva. Head. Antenna short, smooth, and cylindrical with a single, simple seta at a half. Seta A with 2-3 branches, B bifid at a half, C usually double but in one specimen single on one side and with 3 branches on the other; d with 3 branches. Mentum with 10-11 teeth on either side of the central tooth, the lower 3 more widely spaced. *Thorax* with stellate setae, but sometimes these setae much reduced or absent. *Abdomen.* Comb a row of 8-11 spines which have small secondary denticles at the base, 2 of them being longer and stouter than the rest, giving the spine a trifid appearance under the low powers of the microscope. Siphon dark to tip and with an index of $1\frac{1}{2}$ in crushed specimens. Pecten composed of 8-11 triangular spines which have fine ventral denticles and sometimes a few dorsally; one spine is usually placed just beyond the subventral tuft which has 2-3 branches, finely plumose under high powers of microscope, about the length of the diameter of the siphon at point of attachment, and placed at a half. Saddle chitinated but not complete; lower caudal seta single, upper with 2-3 branches; lateral seta with 2-3 branches, finely plumose under high power, and about twice the length of the saddle. Ventral brush with 4 pairs of bifid setae. Gills sausage-shaped, sub-equal, with the upper pair 3-5 times the length of the saddle.

Described from 10 males and 4 females, 12 larval pelts bred from tree holes in the City Park, Nairobi, Kenya, and 2 ♀ from Nairobi (*Dr. V. G. L. van Someren*, 1924).

The type male and female and paedotypes will be deposited in the British Museum (N.H.).

Aedes (Stegomyia) deboeri Edwards, 1936.

Larva. Head. Length and breadth about the same. Clypeal spines long and slender. Antenna smooth, cylindrical, and about one-third the length of the head; tuft a small single seta at two-thirds. Seta A usually with 2 branches, B and C usually single, but C sometimes bifid beyond a half, d with 5-8 branches. Mentum with 10-11 teeth on either side of the central tooth; the basal 3 more widely spaced. *Thorax.* Stellate setae present, sometimes large and conspicuous, but very often much reduced, and sometimes unrecognisable. Short straight spines at the base of the meso- and metathoracic pleural hairs. *Abdomen.* Comb a row of 8-14 sharp-pointed spines which have minute basal denticles. Siphon dark to tip with an index of $1\frac{1}{2}$ in larval pelts, but probably 2 in uncrushed specimens. Pecten an uneven row of 9-15 rather long, pointed spines, which are about the same colour as the siphon; 1-3 of the more distal spines widely spaced and placed beyond the subventral

tuft, the most distal spine may reach to near the apex of the siphon. The spines may be simple, or have few or many fine ventral, and sometimes a few dorsal, denticles; sometimes the apical 2-3 denticles may be coarser than the rest. The denticles on both comb and pecten are very inconspicuous under low powers of the microscope, appearing almost simple. Subventral tuft placed at two-thirds, bifid, but occasionally a single seta, not quite as long as the diameter of the siphon at point of attachment, and finely plumose. Saddle chitinated, well developed but incomplete. Upper caudal seta with 2 branches, lower single. Lateral seta with 2 sparsely plumose branches which are about 3 times the length of the saddle. Ventral brush with 4-5 pairs bifid setae. Gills sausage-shaped and in larval pelts they vary in length from 2-5 times the length of the saddle.

Pupa. Very similar to that of *A. dendrophilus* Edw. Integument of dorsum of thorax and first few abdominal tergites dark brown, remainder yellow. Paddles infusate with a broad dark mid-rib. Dorsal seta long, single. O, P and R single; O about one-half and R only a little less than the length of P. H, K, S and T single; H about one-third K, which is longer than S and T, which are about equal. Float hair with 6-12 dendroid branches. C II with 2-3 branches; C III single or bifid and both about one-half the length of B; C IV-VII small and single. B II-III single and a little more than one-half the length of the segment; B IV-VII short and single. A II-III minute, fine; A V-VI small but slightly stouter than on the preceding segments, single or split into 2-3 on apical half; A VII nearly as long as A VIII, single or bifid, simple or sparsely plumose; A VIII with 3-4 finely plumose branches and about one-third the length of the paddles. Paddles somewhat pointed with fine denticles extending round most of the margin; seta about one-sixth the length of the paddles.

Described from 13 larval pelts and 5 pupal pelts and many whole larvae. The material in the Medical Research Laboratory, Nairobi, Kenya, was collected from tree holes in Nairobi and the adults were identified from the description in Edwards (1941) and dissections of the male terminalia. The paedotypes will be deposited in the British Museum (N.H.).

Aedes (Stegomyia) deboeri subsp. *demeilloni* Edwards, 1936 (figs. 3-7).

A large series of *A. deboeri* subsp. *demeilloni* has been collected from Bwamba, Toro District, Uganda, by Dr. A. J. Haddow, Yellow Fever Research Institute, Entebbe, and from Kaimosi, North Kavirondo, Kenya, by Dr. Garnham and Mr. Harper, Medical Department, Kenya. The adults have been identified from the description given by Edwards (1941) and dissections of the male terminalia.

The name *demeilloni* is adopted here as being applicable to this material, but, in view of the fact that *demeilloni* was described from Zululand, and that the description of the larva and adult here given do not agree with the description given by Hopkins (1936) and Edwards (1941), it is possible that the Uganda and Kaimosi material represents a racial form; however, owing to its variability it is considered inadvisable to give it a new designation at this stage.

On examining the larvae of the Bwamba and Kaimosi specimens, it was found that there was a slight discrepancy in the description of the larva of *demeilloni* given by Hopkins (1936), taken from de Meillon (1929). The Bwamba and Kaimosi larvae run down to *A. dendrophilus* in the key given by Hopkins (1936), thus differing from the description given for *demeilloni* by having minute instead of coarse basal denticles on the comb spines.

It became evident on examining the Bwamba and Kaimosi material that the existing descriptions of the adult, pupa and larva were inadequate, if this

material is to be taken as identical with *demeilloni*, as a great range of variation was noted in all stages.

The following description giving the range of variation is largely taken from a manuscript sent to me by Dr. Haddow, to whom I am also indebted for the use of his figures.

Egg (fig. 3). Black, cigar-shaped; one end slightly blunter than the other and one side slightly flattened. Surface with rather coarse and irregular reticulations.



FIG. 3.—Egg of *Aedes (Stegomyia) deboeri* subsp. *demeilloni* Edwards.

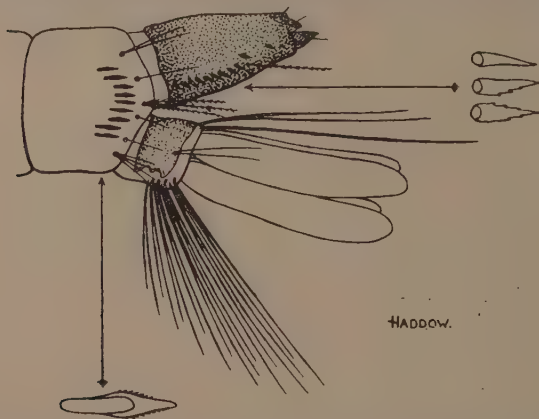


FIG. 4.—Larva of *Aedes (Stegomyia) deboeri* subsp. *demeilloni* Edwards.

Larva (fig. 4). Very similar to *deboeri*. No reliable difference being noticed. Colour greenish-white; head saddle and siphon dark brown. Head as in *deboeri*. Seta A with 2 branches, B and C usually single, C very seldom bifid beyond a half, *d* with 4–8 branches, *e* and *f* single. Mentum with 8–9 teeth on either side of the central tooth. Thorax as in *deboeri*. Abdomen. Comb of 6–12 spines, as in *deboeri*, with fine basal denticles. Siphon rather conical and dark to tip. Index in life about 2; the least pressure of the coverslip changes its shape—it becoming somewhat angulate in the middle and the index falls to $1\frac{1}{2}$. The pecten extends to beyond a half and consists of 8–14 spines, which are often simple and

often with small denticles on one or both sides, delicate and about the same colour as the siphon. The spines are fairly widely spaced and the subterminal is distinctly more widely spaced and usually lies out of alignment with the others and above the tuft. The terminal spine, sometimes absent, is placed well beyond the subventral tuft. There never seems to be more than one spine placed beyond the tuft, thus differing from *deboeri*, which may have from 1-3 beyond the tuft. In most specimens examined the subventral tuft was a single plumose seta, a little less than the diameter of the siphon; very occasionally this hair had 2 branches on both sides of the siphon. Anal segment with a short, dark, well-developed but incomplete saddle. Upper caudal seta with 2 branches, lower single. Lateral seta usually with 2 branches, but sometimes single or with 3 branches, plumose, and about $2\frac{1}{2}$

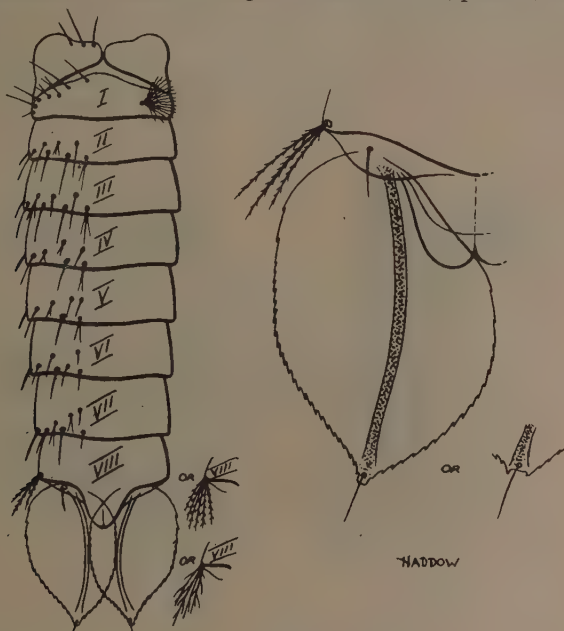


FIG. 5.—Pupa of *Aedes (Stegomyia) deboeri* subsp. *demeillonii* Edwards.

times the length of the saddle. Ventral brush with 4-5 pairs of bifid setae. Gills sub-equal, sausage-shaped, and from 3-4 times the length of the saddle.

Pupa (fig. 5). Colouring and setae on thorax and first abdominal tergite the same as in *deboeri*. Paddles pale yellow. C II with 2-3 branches very nearly as long as B; C III single or with 2-3 branches about half the length of B; C IV-VII short, single or with 2-3 branches. B II-III single and a little more than half the length of the segment; B IV-VII single, less than half the segment. A II-III minute; A IV-VI small but stouter than on the preceding segments; A VII one-third to one-half the length of A VIII, single or bifid, simple or very sparsely plumose and sometimes the branches are split again distally; A VIII one-half to two-thirds as long as the paddles and with 2-6 plumose branches, sometimes dendroid and sometimes sparsely branched. Often different types of setae on different sides of the same pupa. Paddles as in *deboeri*. Seta about one-fifth the length of the paddles.

♀ (fig. 6). Head mainly black with a median silvery white line sometimes sub-divided by a narrow black line, a margin of white scales round eyes meeting small lateral white

patches. Palpi white tipped. Tori with silvery white scales. Clypeus bare and proboscis black. Thorax black. Two large lateral patches anteriorly, pear-shaped, rather rounded behind, silvery white, reaching margin at scutal angle, and for a short distance in front. These 2 patches rather differently shaped to those of *deboeri*, being more rounded both before and behind. Two posterior lateral yellowish lines almost meeting the posterior points of the lateral patches; a small white spot in the middle of the front margin; a median white or yellowish line which usually forks round, but which sometimes does not quite meet the line of yellow scales round the bare space in front of the scutellum. The median line may be continued to meet the median white spot, but usually stops about the middle, or may only just reach as far as the posterior points of the 2 lateral white patches. White supra-alar area usually small, rarely meeting the lateral lines. Scutellar scales broad, flat, and silvery white, sometimes with a few broad flat black scales on the middle lobe. Abdomen. Black scales of tergites with a purplish gloss. Silvery tergal markings

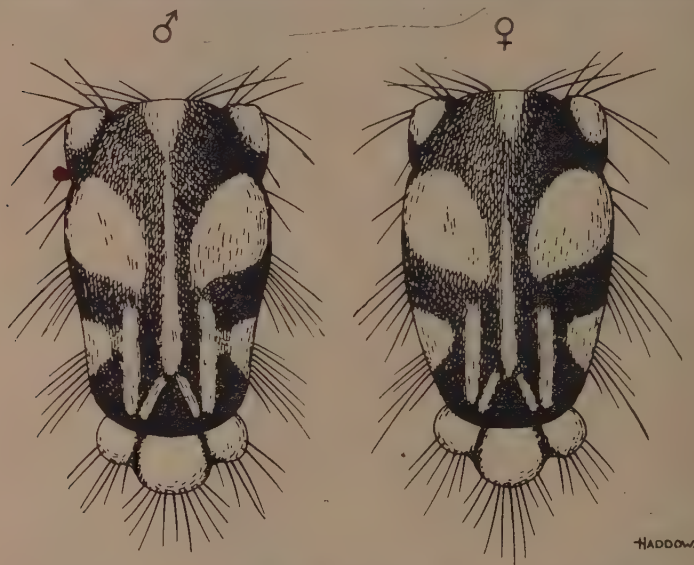


FIG. 6.—Thorax of *Aedes (Stegomyia) deboeri* subsp. *demeiloni* Edwards.

very variable. Tergites 4-6 usually with broad silvery white basal bands which are occasionally reduced to large basal median patches; 3 with a basal median patch or band; 7 with a median basal silvery spot. Large silvery white lateral patches on tergites 1-7. Sternites black with narrow basal silvery bands. Legs mainly black. Fore femora black, sometimes with a narrow white basal line below to about one-third or less; middle femora black with a large silvery spot at tip above which may extend back to a point on the anterior surface and sometimes meeting a short, narrow, ventral stripe; hind femora white all round on the basal half, ending in a point on the anterior surface, black on the apical half, but sometimes a dark dorsal line extending back to two-thirds or almost to the base. A large silvery white spot at tip is continued to a point below, but sometimes there is also a small white spot above. In some specimens the hind femora have a silvery white pre-apical spot which is either completely fused with, or almost separate from, the basal white area. Fore tibiae black, sometimes with a narrow basal band extended to a point beneath; middle tibiae all black with sometimes a small pointed basal spot below and, if present,

placed more posteriorly than on the fore tibiae; hind tibiae black with a white basal line below reaching to a third. Front tarsi with segments 1-2 narrowly or broadly white at base; middle tarsi with the first segment narrowly white at base, or narrowly white below and widely above, even to a third, second segment all white above, mainly black below or only at tip; hind tarsi with narrow or broad white rings on segments 1-3, 4 may be all white or white above and black below, or it may have a complete narrow black ring at the tip, fifth all white, sometimes with a few black scales at tip.

♂. *Head* mainly silvery white with 2 black patches above and 2 smaller ones on either side. Sometimes the head is almost entirely silvery white, the black patches being much reduced and of greyish colour, owing to an admixture of white scales. Median black line more pronounced than in the female. In most males the proximal white band on the shaft of the palps is absent but sometimes represented by a few white scales above; in a few specimens it is represented in a well-marked condition. *Thorax*. Essentially the same as the female, differing as follows: median line usually, but not always, continuous, usually



FIG. 7.—Terminalia of *Aedes (Stegomyia) deboeri* subsp. *demeilloni* Edwards.

narrow in front and widening behind and often sub-divided by a narrow, very thin, black longitudinal line. It usually forks round the bare space and may be very prominent in this area, yellowish throughout or white anteriorly. Supra-alar patches larger than in the female and sometimes fused with the lateral white lines, in which case the area of fusion is yellowish. *Abdomen* with the first white band usually on tergite 3; tergite 7 with a silvery white spot and 8 with 2 dorsal lateral silvery spots. *Legs* as in the female. *Terminalia* (fig. 7). Essentially the same as that described by Edwards for *deboeri*. Usually 2, but in one specimen 3, small spines on the inner edge of the basal plaque and placed on a slight elevation. Teeth of the phallosomes recurved and one is distinctly longer than the others. Lobes of the tergites with 10-12 hairs.

. Described from 54 adults, larval pelts and pupal pelts and some whole larvae, pupae and eggs collected by Dr. Haddow from Bwamba, Uganda, and 20 adults and larval pelts collected from Kaimosi, Kenya, by Dr. Garnham and Mr. Harper.

Aedes (Aedimorphus) kapretwae Edwards, 1941 (fig. 8).

Larva. Head about as broad as long. Antenna about half the length of the head, spiculate, and slightly infusate; tuft at a half and composed of 3-5 finely plumose setae. Setae A, B and C plumose and with 8-13, 5-8 and 7-12 branches respectively; *d* small with 7-10 fine branches. Mentum (fig. 8) triangular with 11-12 teeth on either side of the central tooth, the basal 2 smaller and more widely spaced. Abdomen. Comb a patch of 20-28 small pale scales, which are fairly broad and with a long apical fringe. Siphon usually pale brown and with nearly straight sides, only slightly swollen basally and tapering gradually from base to apex. Index 3-3.25. Pecten reaches to just before the tuft and is composed of 16-18 dark spines each with 2-3 small basal denticles. Subventral tuft at a

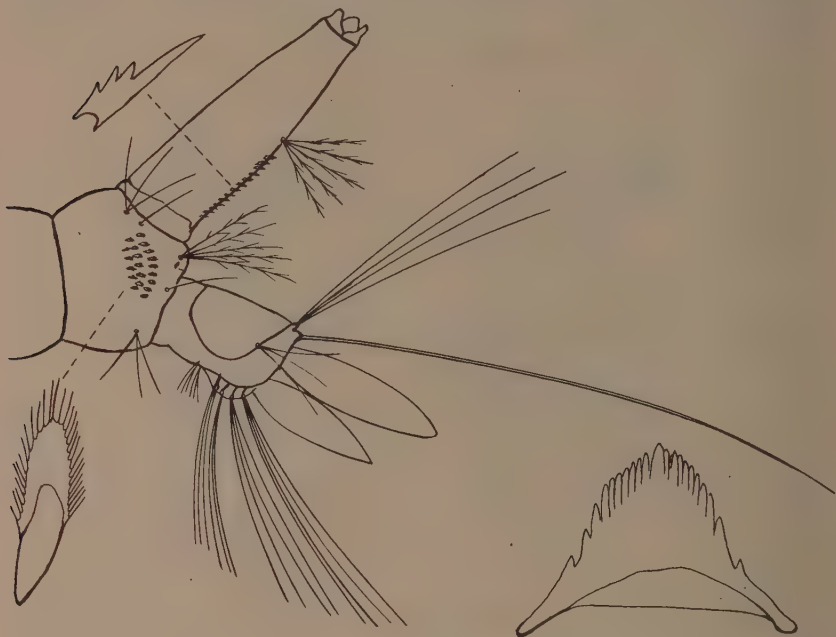


FIG. 8.—Larva of *Aedes (Aedimorphus) kapretwae* Edwards.

half and is composed of 4-5 finely plumose branches which are a little longer than the diameter of the siphon at point of attachment. Anal segment with saddle chitinised but incomplete. Lower caudal seta single, upper with 4-5 branches. Lateral seta simple, with 2-6 branches. Gills variable and 1-3 times the length of the saddle. Ventral brush of 4 paired tufts of 3-4-branched setae in the barred area and 2 unpaired setae outside the barred area.

Breeding places : tree holes at altitudes over 7500 ft.

Collected by Dr. P. C. C. Garnham, Mr. J. O. Harper, and Mr. R. B. Highton, Medical Department, Kenya.

Described from 6 larval pelts and 11 whole larvae.

Aedes (Aedimorphus) capensis Edwards, 1925 (fig. 9).

The larva described below is that of type A of Edwards (1941). It is very similar to that of *kapretwae*, from which it may be distinguished by the shape of the mentum and the siphon.

Head as in *kapretwae*. Antennal tuft usually with 6 branches. Setae A, B, and C with 10-11, 5-7, and 6-7 branches respectively. Mentum (fig. 9, b) smaller than *kapretwae*, elongated and more pentagonal in shape, with 10-11 teeth on either side of the central tooth, the basal 2 small, widely spaced, more so than in *kapretwae*.

Abdomen as *kapretwae*. Siphon usually heavily chitinated and therefore dark brown or blackish in colour, the basal half swollen, apical half narrower and tapering to apex. Index 3.3-4.5.

Breeding places: tree holes.

Described from numerous larval pelts and many whole larvae collected by Dr. P. C. C. Garnham, Mr. J. O. Harper, and Mr. R. B. Highton.

A. kapretwae and *capensis* are very similar to *A. haworthi* Edw. but may be



FIG. 9.—a. Comb scale of *A. haworthi* Edw. b. Mentum of *A. capensis* Edwards.

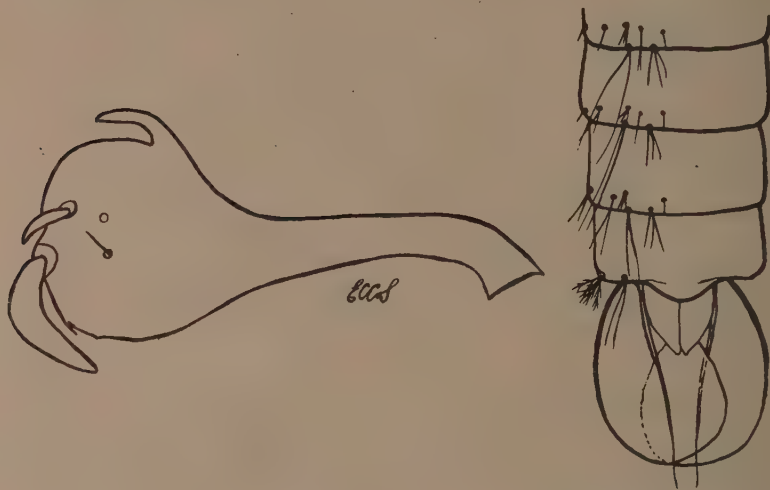
distinguished by the shape of the comb scales, which in *kapretwae* and *capensis* are fairly broad with a long apical fringe, while those of *haworthi* are narrow with a short apical fringe (fig. 9, a).

Aedes (Aedimorphus) pseudotarsalis sp. n. (figs. 10, 11, 12).

No obvious differentiating character can be seen that will distinguish the adult of this species from that of *A. tarsalis* Newstead, except that *pseudotarsalis* has sometimes, but not always, a few (1-3) broad whitish scales on the post-spiracular area, thus running down in Edwards (1941) to *A. albocephalus* Theobald, from which it can be differentiated by the male terminalia. The larvae are nevertheless quite distinctive, having a row of appressed spines near the apex of the siphon.

♀. *Head*. Decumbent scales on the vertex all narrow, mainly pale yellow but with a patch of black scales in the middle. Upright scales black. Tori pale brown with a few pale scales and a few dark ones on the inner border. Clypeus dark brown and bare. Palpi and proboscis black. *Thorax* reddish-brown. Scales on scutum all narrow and mainly dark brown, but with golden scales forming a definite pattern and a few scattered over the whole area. Pattern of golden scales as follows:—a fairly broad stripe of golden scales along front margin, a patch on scutal angle, and a pair of small golden spots about the

middle. Golden scales round the bare space in front of scutellum and on the supra-alar region. Scales on *apn* narrow and white; *ppn* with a few broad pale scales below, mostly narrow and black above but with a few narrow golden scales above near margin of scutum. Paratergites with broad flat white scales. A few post-spiracular scales, sometimes absent, and a few sub-spiracular scales. A patch of white scales on upper mesepimeron and 2 patches on sternopleurae. Scutellum with broad white scales on all lobes. *Abdomen*. Black scales on abdomen sometimes with a purplish gloss. Tergites unbanded, but with basal white lateral patches on segments 1-7 which are hardly visible from above. Sternites white with broad black apical bands. *Legs* black. All femora with white knee-spots. Fore femora black all round except for a white ventral line; anterior surfaces of mid femora black, about half-way along the posterior surface the white ventral line gradually broadens out towards the base to fill the whole surface; anterior surfaces of hind femora white to three-quarters or more and ending in a point distally, posterior surfaces white to



FIGS. 10-11.—10. Style; 11. Pupa of *Aedes (Aedimorphus) pseudotarsalis* sp. n.

three-quarters or less, black at tip and a dark dorsal line to base. All tibiae black with a white spot at apex, that on hind tibiae twice as long as broad. All tarsi dark, unbanded. *Wing*. Scales dark with a small white spot at the base of the costa.

♂. Ornamentations as in the female but with the lateral white patches on the abdomen more dorsal, and on segments 4-6 they may extend towards the middle to form a white band. *Terminalia* (fig. 10) very like that of *A. tarsalis*. The more proximal portion of the style is probably stouter, resembling that figured by Edwards (1941) for *A. filicis* I. & de M. Style greatly enlarged distally, somewhat quadrate, with a small horn, a short spine, and a leaf.

Pupa (fig. 11). Integument of dorsum of thorax and abdominal segments I-II slightly infusate; paddles pale. The abdomen is covered with small chitinous plaques. Trumpets slightly darker than the thorax. Dorsal seta long, with 5-6 branches. Post-ocular setae; upper with 4-5 branches, median bifid, lower single or branching into 2 just beyond a half. Postero-thoracic; O with 6-9 branches, P single, R with 6-7 branches and about three-quarters the length of O and P. Float hair of 15-18 dendroid branches. H

and K single, H about one-third the length of K. S and T bifid or trifid, T slightly shorter than S. C II with many fine simple branches (about 36), C III with 6-8 and C IV-VII with 2-6 branches. B II and III single and about the length of the segment, B IV-VI with 2-3 branches which are longer than the segment, B VII single or with 2 branches and about half the length of the segment. A II-VI a minute simple hair, A VII with 2-3 branches which are usually simple but may be sparsely plumose and about two-thirds the length of A VIII, which has 4-5 sparsely plumose branches, about one-quarter the length of the paddles. Paddles broad beyond a half, with an external buttress and margin minutely denticulate, strong mid-rib, seta single and one-sixth the length of the paddles.

Larva (fig. 12). *Head*. Antenna pale, spiculate, and with a tuft of 10 finely plumose setae just below a half. Seta A with 10-15, B with 6-8, and C with 7-9 plumose branches;

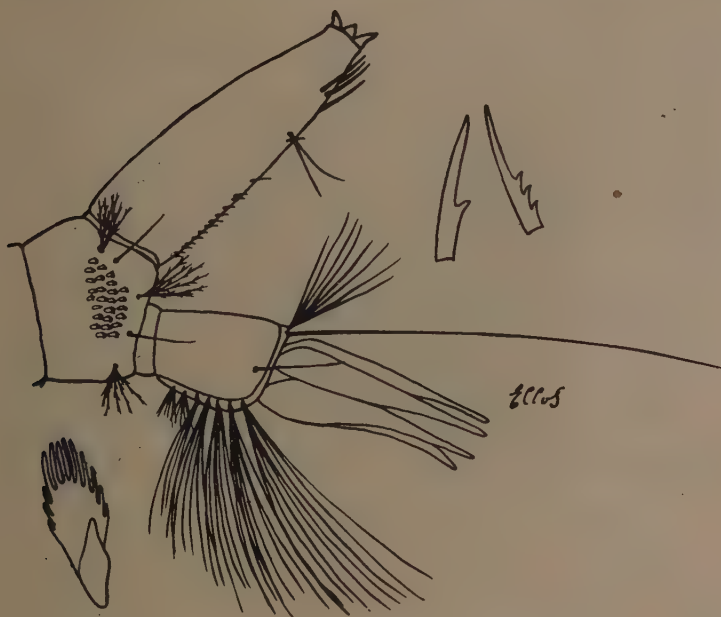


FIG. 12.—Larva of *Aedes* (*Aedimorphus*) *pseudotarsalis* sp. n.

d small and with about 11 branches. Mentum with 17-20 teeth on either side of the central tooth. *Abdomen*. Comb a patch of 29-33 scales. Siphon pale with a ventral semicircle of long black spines near the apex; index $3\frac{1}{2}$ -4. Pecten of 16-21 fairly long dark spines, the last 2-3 more widely spaced and in one specimen one of the more widely spaced spines is placed beyond the subventral tuft. The most distal spine is always simple and sometimes all the more widely spaced spines are simple, the rest have from 1-3 denticles. Subventral tuft usually placed just beyond the pecten at two-thirds, with 2-3 simple branches which are not quite as long as the diameter of the siphon at point of attachment. Saddle complete; lateral seta single, simple, and about the length of the saddle. Ventral brush with 5 paired setae each with 8 branches and 2 unpaired tufts outside the barred area. Gills long, narrow, and lanceolate, about twice the length of the saddle.

Described from 12 males, 12 females, 22 larval pelts and 19 pupal pelts

collected from a murram pit and rock holes, Nairobi, Kenya, June 1942. Larvae also recorded from Nyeri and from a rock pool, Nanyuki, Kenya.

The types and paedotypes will be deposited in the British Museum (N.H.).

The following notes indicate the position where the larvae and adults will come in the keys as given in (Hopkins (1936), Edwards (1941)).

Key to the Known Larvae of the Genus *Aedes*, Vol. 1, pp. 95-8.

To eliminate any difficulty that may be experienced in running down *deboeri* subsp. *demeilloni*, and *keniensis*, in the key, due to the fact that they have sometimes no recognisable stellate setae on the thorax, in the following notes, each species is included twice; thus they can be run down from section 8 whether they have or have not stellate setae on the thorax.

At the end of the second alternative in section 1 for 4 read 1a and insert a new section as follows :—

- 1a. Siphon with a ventral row of appressed spines near the apex *pseudotarsalis* n.
Siphon without such spines 4.

At the end of first alternative of section 10 after *dendrophilus* (p. 118) add *deboeri* and subsp. *demeilloni*.

At the end of second alternative of section 10 for *unilineatus* (p. 117) read 10a and insert a new section as follows :—

- 10a. Comb spines with numerous fine basal denticles forming a broad fringe
which reaches to near the apex of the spine *fraseri*.
Comb spines with a few coarse basal denticles 10b.
10b. Anal segment with a complete saddle. Setae of ventral brush not
branched *unilineatus* (p. 123).
Anal segment with incomplete saddle. Setae of ventral brush bifid
keniensis n.

Delete first alternative of section 11 and substitute :—

11. Comb spines and pecten spines completely simple or appearing so; denticles, if present, minute and inconspicuous under high powers of the microscope 11a.

Add a new section as follows :—

- 11a. Pecten spines regularly spaced except beyond the tuft
bambusae (p. 121), *deboeri* and subsp. *demeilloni*.
Pecten spines irregularly spaced and placed in groups of 2-5 spines
bambusae.¹

Delete section 14 and add a new section as follows :—

14. Pecten of 8-11 triangular spines with minute denticles both dorsally and ventrally 14a.
Pecten of 14-20 spines with conspicuous ventral denticles; dorsal side of these spines simple or nearly so *aegypti* (p. 110).
14a. Lower caudal seta single. *keniensis* n.
Lower caudal seta with 2-3 branches *simpsoni* (p. 114).

¹ Probably a new subspecies of *A. deboeri*. See Garnham, Harper, and Highton, *Mosquitoes of the Kaimosi Forest, Kenya Colony, with Special Reference to Yellow Fever*. (In press.)

Delete section 51 and 52 and add a new section as follows :—

51. Comb of about 80 scales. Pecten spines each with 2-3 lateral denticles; index about $4\frac{1}{2}$ *apicoannulatus* (p. 129).
 Comb scales less, about 20-40 52.
 52. Pecten spines with 2-3 basal denticles; about 20-30 comb scales 52a.
 Pecten spines with one lateral denticle; about 40 comb scales *simulans* (p. 130).
 52a. Comb scales rather narrow and with a short fringe *haworthi* (p. 128).
 Comb scales broader, with a longer apical fringe. 52b.
 52b. Mentum triangular (fig. 8). Basal half of siphon not greatly swollen; index 3-3.25 *kapretwae*.
 Mentum pentagonal (fig. 9, b). Basal half of siphon swollen; index 3.3-4.5 *capensis*.

Key to the Ethiopian Species of Subgenus *Stegomyia*, Vol. 3, pp. 126-8.

Delete section 14 and 15 and substitute :—

14. White markings on legs with a metallic sheen 15.
 Pure snow-white markings on legs; no metallic sheen *fraseri* Edw. (p. 139).
 15. Hind tibiae white at the base beneath and with a silvery patch on outer surface at one-third the length. Scales bordering bare space in front of scutellum usually black but very occasionally a few white scales present *apicoargenteus* Theo. (p. 136).
 Hind tibiae black at the base beneath; white patch on outer surface present. A broad band of yellow scales bordering bare space in front of scutellum *schwetzi* Edw. (p. 139).

Delete second alternative of section 16 and substitute :—

16. Scutum with main white markings smaller, more crescent-shaped, or large and rounded, with or without a continuous median yellow line. Hind femur with a small or large white spot at tip, sometimes extended to a point below 20.

Delete section 23 and substitute :—

23. Hind tibia all black 23a.
 Hind tibia with a white line at the base below *deboeri* Edw. (p. 149).

Insert a new section as follows :—

- 23a. Third hind tarsal segment all black *masseyi* Edw. (p. 146).
 Third hind tarsal segment with a narrow white basal ring *keniensis* n.

Key to the Ethiopian Species of Subgenus *Aedimorphus* and *Ochlerotatus*, Vol. 3, pp. 158-60.

At the end of first alternative of section 22 after *tarsalis* Newst. (p. 174) add *pseudotarsalis*.

ACKNOWLEDGMENTS.

I wish to thank Dr. A. J. Haddow for allowing me to use his figures of *A. deboeri* subsp. *demeilloni*, my husband for providing some of the figures, and Dr. V. G. L. van Someren for much helpful advice.

REFERENCES.

- EDWARDS, F. W., 1941, *Mosquitoes of the Ethiopian Region*. 3.
HOPKINS, G. H. E., 1936, *Mosquitoes of the Ethiopian Region*. 1.
—, 1943, "Mosquitoes of the Ethiopian Region"—Notes and Corrections.
Bull. ent. Res. 33 : 175-9.
INGRAM, A., and DE MEILLON, B., 1929, Descriptions of the Larvae and Pupae, not
Hitherto Described, of Certain South African Mosquitoes. *Publ. S. Afr.*
Instit. Med. Res. No. 23 : 157-70.

Eu-344
Vol. 96. Part 8. Pp. 125-149, 47 figs.

15th May, 1946.

THE
TRANSACTIONS
OF THE
ROYAL
ENTOMOLOGICAL SOCIETY
OF
LONDON

World List abbreviation: Trans. R. ent. Soc. Lond.

CONTENTS

	PAGE
X HINTON, H. E., B.Sc., Ph.D., F.R.E.S. A synopsis of the Brazilian species of <i>Elsianus</i> Sharp (Coleo- ptera, ELMIDAE)	125-149, 47 figs.

LONDON:

PUBLISHED BY THE SOCIETY AND
SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 7s. 0d.

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Founded, 1833. Incorporated by Royal Charter, 1885.

PATRON—HIS MAJESTY THE KING.

OFFICERS and COUNCIL for the SESSION, 1946–1947.

PROF. G. D. HALE CARPENTER, M.B.E., D.M., *President*.

W. J. HALL, D.Sc.
C. B. WILLIAMS, M.A., D.Sc. } *Vice-Presidents*.
H. B. WILLIAMS, LL.D.

A. WELTI, *Treasurer*.

N. D. RILEY, *Secretary*.

Other Members of Council.

C. H. ANDREWES, F.R.S.	CAPT. R. A. JACKSON, R.N.
J. W. EVANS, M.A., D.Sc.	MISS C. E. LONGFIELD.
G. FOX-WILSON, N.D.H.	SIR GUY A. KN MARSHALL, K.C.M.G.,
R. M. GREENSLADE.	D.Sc., F.R.S.
FRANCIS HEMMING, C.M.G., C.B.E.	G. E. J. NIXON, B.A.
H. E. HINTON, B.Sc., Ph.D.	J. F. PERKINS, B.Sc.

F. J. GRIFFIN, A.L.A., *Registrar*.

Finance and House Committee.

G. FOX-WILSON, N.D.H. (*Chairman*).

J. W. EVANS, M.A., D.Sc.	W. RAIT-SMITH.
FRANCIS HEMMING, C.M.G., C.B.E.	O. W. RICHARDS, M.A., D.Sc.
H. E. HINTON, B.Sc., Ph.D.	

Publication and Library Committee.

W. J. HALL, D.Sc. (*Chairman*).

H. E. HINTON, B.Sc., Ph.D.	J. SMART, B.Sc., Ph.D.
B. M. HOBBY, M.A., D.Phil.	W. H. THORPE, M.A., Sc.D.
J. F. PERKINS, B.Sc.	

Committee on Generic Nomenclature.

FRANCIS HEMMING, C.M.G., C.B.E. (*Chairman*).

W. A. F. BALFOUR-BROWNE, F.R.S.E.	O. W. RICHARDS, M.A., D.Sc.
K. G. BLAIR, D.Sc.	N. D. RILEY (<i>Secretary</i>).

Committee for the Protection of British Insects.

H. M. EDELSTEN, O.B.E. (*Chairman*).

R. B. BENSON, M.A.	A. M. MASSEE, D.Sc.
E. A. COCKAYNE, M.A., M.D., F.R.C.P.	THE HON. MIRIAM ROTHSCHILD.
CAPT. R. A. JACKSON, R.N.	W. H. THORPE, M.A., Sc.D.
COL. F. A. LABOUCHERE.	N. D. RILEY (<i>Secretary</i>).

The Executive Officers of the Society are *ex-officio* members of all Committees.

DELEGATES OF THE SOCIETY TO :

- 1. British National Committee for Biology** (Royal Society).
Mr. Francis Hemming, C.M.G., C.B.E., appointed 1945.
Dr. V. B. Wigglesworth, M.A., B.Ch., M.D., F.R.S., appointed 1943.
- 2. Local Committee of Management of Wicken Fen.**
Mr. H. M. Edelsten, O.B.E. [nominated by Committee for the Protection of British Insects].
- 3. National Trust for Places of Historic Interest or Natural Beauty.**
Mr. H. M. Edelsten, O.B.E., appointed 1944.
- 4. New Forest Association.**
Mr. W. Fassnidge, appointed 1934.
- 5. New Forest Joint Committee.**
Mr. W. Fassnidge, appointed 1939. Dr. F. J. Killington, D.Sc., A.L.S., appointed 1939.
- 6. Royal Meteorological Society. Phenological Committee.**
Dr. C. B. Williams, M.A., D.Sc., appointed 1937.
- 7. Biology War Committee.**
Prof. P. A. Buxton, M.A., F.R.S., appointed 1941.
- 8. Council for the Promotion of Field Studies.**
Dr. W. H. Thorpe, M.A., Sc.D., appointed 1944.
- 9. Joint Bioclimatic Committee.**
Dr. B. P. Uvarov, C.M.G., D.Sc., appointed 1945.
Dr. C. B. Williams, M.A., D.Sc., appointed 1945.

A SYNOPSIS OF THE BRAZILIAN SPECIES OF *ELSIANUS* SHARP (COLEOPTERA, ELMIDAE)

By H. E. HINTON, B.Sc., Ph.D., F.R.E.S.

(Department of Entomology, British Museum (Natural History).)

Manuscript received 27th March, 1945.

(Read 7th November, 1945.)

WITH 47 TEXT-FIGURES.

THE greater portion of the material which forms the basis of this synopsis was collected by Dr. Fritz Plaumann in Santa Catharina, Nova Teutonia, in 1936. A few additional species were collected by me in the Amazon Basin in 1937. I have also been able to examine cotypes of all but one of Grouvelle's species through the kindness of Mons. A. Villiers of the Muséum National d'Histoire Naturelle, Paris.

Until now only six species of *Elsianus* had been described from Brazil. In this paper a further 12 species are added to the Brazilian fauna. A list of these is given below together with the number of specimens of each examined. I have included one species collected in the coastal region of French Guiana because it is very close indeed to one of the Brazilian species and because, as far as the ELMIDAE are concerned, this region appears to be part of the same faunal zone as the Amazon Basin.

List of material.

1. <i>E. tereus</i> sp. n.	French Guiana	2
2. <i>E. antiquus</i> Grouv.	Brazil	—
3. <i>E. amazonicus</i> Hint.	Matto Grosso	8
4. <i>E. thorpei</i> sp. n.	Amazonas	9
5. <i>E. tityrus</i> sp. n.	"	8
6. <i>E. salti</i> Hint.	São Paulo	2
7. <i>E. granosus</i> (Grouv.)	Rio de Janeiro	2
8. <i>E. isus</i> sp. n.	Santa Catharina	30
9. <i>E. pubescens</i> Grouv.	" "	1
10. <i>E. aristaeus</i> sp. n.	" "	2
11. <i>E. amarus</i> sp. n.	" "	11
12. <i>E. aleus</i> sp. n.	" "	2
13. <i>E. aeolus</i> sp. n.	" "	3
14. <i>E. zamus</i> sp. n.	" "	69
15. <i>E. plaumanni</i> sp. n.	" "	7
16. <i>E. saleius</i> sp. n.	" "	2
17. <i>E. celsus</i> sp. n.	" "	20
18. <i>E. aequalis</i> Hint.	" "	110
19. <i>E. codrus</i> sp. n.	" "	13
— Unnamed specimens	" "	8

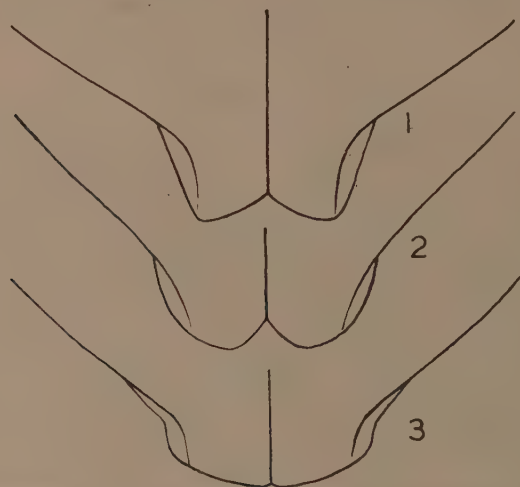
Total number of specimens examined 309

TRANS. R. ENT. SOC. LOND. 96. PART 8. (MAY 1946.)

I

The unnamed specimens included in the list are females which are badly rubbed, or caked with earth, or otherwise damaged.

The present study has shown that the generic diagnosis previously given by me (1940) must now be emended in certain particulars. The front tibia always has a single longitudinal fringe of long, golden tomentum. The middle tibia always has two similar fringes of which the antero-dorsal is invariably



FIGS. 1-3.—Dorsal view of apices of elytra. (1) *Elsianus amazonicus* sp. n. (2) *E. isus* sp. n. (3) *E. zamus* sp. n.

the shorter. The hind tibia may have one or two fringes, the second or antero-ventral fringe when present being very short and very close and parallel to the longer postero-ventral fringe. Sublateral carinae are rarely present on the elytra, but in *E. granosus* (Grouv.) the ninth, seventh, and fifth intervals are carinate and the third is carinate near its base.

All illustrations were made by me with the aid of a camera lucida; and lines next to figures refer to a length of 0.20 mm. unless otherwise indicated.

Key to the Brazilian species of *Elsianus*.

1. Pronotum with a prominent oval gibbosity near base in front of scutellum. Male with a short, low, sharp carina before apical third of inner (ventral) side of hind tibia. (Pronotum and elytra with numerous microscopic setae between the usual recumbent hairs. Pronotum with sublateral carina present on basal five-sixths, broad, strongly elevated, and with inner or dorso-mesal margin sharp; disk coarsely and densely granulate. Elytral apices (fig. 1) obliquely truncate so that most anterior part of each apex is mesal and the apices together form a V-shaped emargination.) Matto Grosso, Porto Velho *E. amazonicus* Hinton (1945).
- Pronotum without a gibbosity near base in front of scutellum. Male without a carina on inner or ventral side of hind tibia 2.
2. Elytra with fifth, seventh, and ninth intervals carinate; third interval carinate on about basal third. (Pronotum with a broad and shallow

median longitudinal impression; sublateral carina broad, very strongly elevated, and extending to anterior fifth of sides.) Rio de Janeiro

E. granosus (Grouv.) (1896).

- Elytra with all intervals flat or only feebly convex 3.
3. Elytra with apices (fig. 2) noticeably dehiscent. Pronotum with a narrow and feeble median longitudinal line extending from near base to about anterior third. Male with numerous testaceous hairs on labrum which are about as long or longer than labrum and with inner (posterior) spur of hind tibia (fig. 8) broadly dilated. S. Catharina, Nova Teutonia
E. isus sp. n.
- Elytra with apices (fig. 3) taken together broadly rounded or nearly truncate, never strongly dehiscent. Pronotum without or only with a very indistinct median longitudinal line. Male with testaceous hairs on labrum much shorter than labrum and inner spur of hind tibia not dilated and not, or only scarcely, broader than outer spur 4.
4. Pronotum and elytra with numerous short but very distinct (mag. $\times 75$) setae between the recumbent hairs. Male genitalia with parameres short and median lobe produced far beyond their apices. Species 2.5-4.0 mm. long 5.
- Pronotum and elytra without or only with very indistinct (mag. $\times 75$) setae between the usual recumbent hairs. Male genitalia with parameres long or moderately long and median lobe usually not or only slightly produced beyond their apices 7.
5. Pronotum with sublateral carinae scarcely noticeable except at extreme base. Scutellum very strongly convex. Middle tibia with antero-dorsal fringe of tomentum only about one-fifth as long as tibia. Amazonas, Manáos *E. thorpei* sp. n.
- Pronotum with sublateral carinae distinct and their inner edges sharp on basal third or fourth. Scutellum only feebly convex. Middle tibia with antero-dorsal fringe of tomentum at least two-fifths as long as tibia 6.
6. Male genitalia (fig. 13), when seen from side, with median lobe not distinctly swollen near base. Anterior part of prosternum abruptly and strongly bent ventrally. Amazonas, Manáos *E. tityrus* sp. n.
- Male genitalia (fig. 17), when seen from side, with median lobe strongly swollen or inflated near base. Anterior part of prosternum gradually and moderately feebly bent ventrally. French Guiana. *E. tereus* sp. n.
7. Scutellum flat. (Pronotum without sublateral carinae.) S. Catharina, Theresopolis *E. pubescens* Grouvelle (1889).
- Scutellum feebly to strongly convex 8.
8. Middle of pronotal disk distinctly punctate, without granules; granules of pronotum usually confined to sides between margins and sublateral carinae. (Species 4-5 mm. long. Pronotum always with sublateral carinae or sulci, though these may be very fine) 9.
- Middle of pronotal disk with granules which are coarse, dense, and rather flattened to fine, sparse, and more or less spherical. 11.
9. Metasternal disk subgranulate. Abdomen with disk of first sternite deeply and broadly depressed. Male (and female?) with anterior angles of labrum prominently produced and tooth-like. (Male with apex of fifth abdominal sternite broadly and deeply depressed; genitalia (fig. 22) with dorsal part of parameres not excavated.) S. Catharina, Nova Teutonia *E. aristaeus* sp. n.
- Metasternal disk finely and sparsely punctate. Abdomen with disk of first sternite not or only scarcely noticeably depressed. Labrum with anterior angles very broadly rounded, not toothed 10
10. Metasternum moderately to strongly, transversely gibbous on anterior

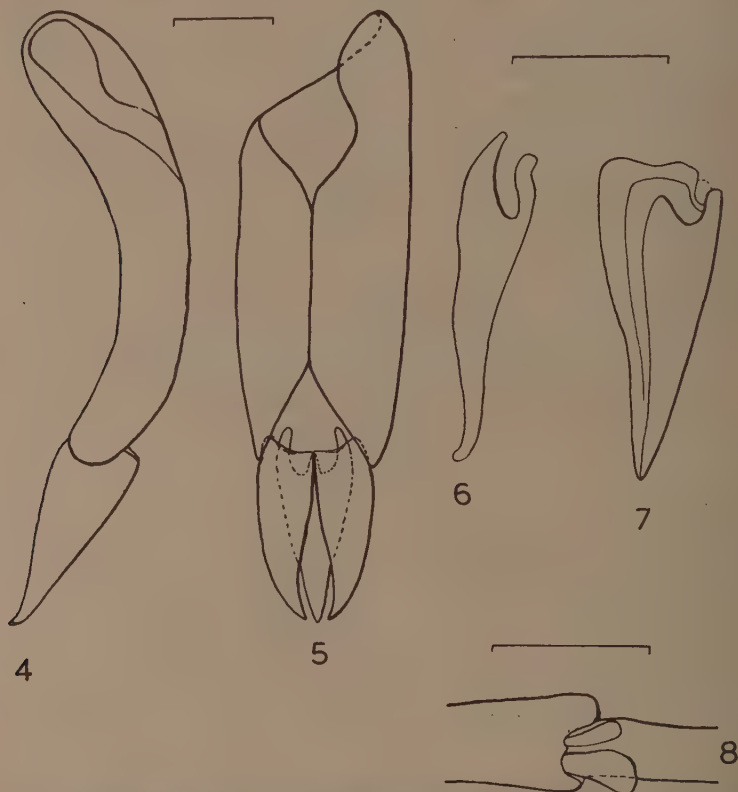
- third. Fifth abdominal sternite not broadly depressed near apex; sometimes with a very narrow, scarcely noticeable depression; apical margin shallowly emarginate at middle. Male genitalia (fig. 25) with dorsal part of parameres not excavated nor densely hairy. S. Catharina, Nova Teutonia *E. amarus* sp. n.
- Metasternum not or only scarcely noticeably gibbous on anterior third. Fifth abdominal sternite with a broad apical depression which is deep in the male and shallow in the female. Male genitalia (figs. 27–28) with dorsal part of each paramere deeply excavated and densely hairy. S. Catharina, Nova Teutonia *E. aleus* sp. n.
11. Pronotum with distinct sublateral carinae 12.
- Pronotum without trace of sublateral carinae or sulci 15.
12. Pronotum with inner or dorso-mesal margin of sublateral carina sharp on basal four-fifths of sides. Male genitalia (figs. 29, 31) with dorsal part of each paramere deeply excavated and densely hairy. (Length, 4.4 mm. Pronotum with granules of middle of disk very fine, more or less spherical, and separated by three to ten diameters. Fifth abdominal sternite with a broad apical depression which is deep in the male and presumably shallow in the female, which is unknown.) S. Catharina, Nova Teutonia *E. aeolus* sp. n.
- Pronotum with sublateral carinae confined to basal half but if extending to apical third (some specimens of *E. zamus*) the disk is densely set with rather coarse and flattened granules. Male genitalia with dorsal part of each paramere not deeply excavated nor densely hairy 13.
13. Length, 5.2 mm. Pronotum with sulcus on mesal side of sublateral carina broad and very deep. Scutellum feebly convex. (Male without an apical depression on fifth abdominal sternite.) São Paulo
E. salti Hinton (1936).
- Length, 4.5 mm. or less. Pronotum with sulcus on mesal side of sublateral carina shallow. Scutellum moderately to strongly convex 14.
14. Pronotum with granules of middle of disk as coarse as to slightly coarser than facets of eyes, round to irregular in outline, distinctly flattened, and usually separated by less than one to two diameters. Fifth abdominal sternite with a narrow apical depression which is deep in males and shallow and often rather indistinct in females. Male with a row of short, acute tubercles on about apical half of ventral (inner) side of middle and hind tibiae (fig. 35). S. Catharina, Nova Teutonia *E. zamus* sp. n.
- Pronotum with granules of middle of disk slightly finer than facets of eyes, more or less spherical, and separated by three to five or more diameters. Fifth abdominal sternite without a distinct apical depression. Male without rows of acute tubercles on middle and hind tibiae. S. Catharina, Nova Teutonia *E. plaumanni* sp. n.
15. Species 3.7 mm. long. Male with anterior margin of labrum very deeply emarginate with angle on each side produced and tooth-like; fifth abdominal sternite with a very deep and broad apical depression; tarsi of front and middle legs with a broad brush of erect, golden hairs near ventral apex of basal segment; genitalia (fig. 40) with median lobe strongly narrowed to apex and pointed. (Middle of pronotal disk with oblong granules and surface between granules conspicuously rugulose.) S. Catharina, Nova Teutonia *E. saleius* sp. n.
- Species 4–5 mm. long. Male with anterior margin of labrum more or less rounded; or truncate, or very feebly emarginate, but not deeply emarginate nor with angle on each side produced and tooth-like; fifth abdominal sternite not depressed or only moderately deeply so; tarsi of front and middle legs without a brush of long hairs near ventral apex of basal segment or, if brush is present (*E. aequalis* Hint.), it is narrow and

- pencil-like; genitalia with median lobe not strongly narrowed towards apex and not sharply pointed 16.
16. Fifth abdominal sternite without an apical depression. Front tibia with tomentose fringe absent only on basal tenth. Middle tibia with antero-dorsal tomentose fringe approximately half as long as tibia, never less than two-fifths as long. Hind tibia with fringe of tomentum extending very nearly to apex. S. Catharina, Nova Teutonia . . . *E. celsus* sp. n.
- Fifth abdominal sternite with a broad apical depression which is deep in the male and moderately (*E. aequalis*) or very (*E. codrus*) shallow in the female. Front tibia with tomentose fringe absent on basal fourth to two-fifths. Middle tibia with antero-dorsal tomentose fringe usually not more than a third as long as tibia, very rarely half as long. Hind tibia with fringe of tomentum absent on apical fifth (not counting apical brush of males of *E. codrus*) 17.
17. Disk of fourth abdominal sternite with fine tomentum absent on at least basal region. Middle tibia with antero-dorsal fringe of tomentum a third or slightly more than a third as long as tibia. Male with a long, thin, pencil-like brush of erect, golden hairs near ventral apex of each of the four basal segments of the front, middle, and hind tarsi, these brushes being particularly conspicuous on first and fourth segments of front and middle tarsi; hind tibia without an apical brush of tomentum. S. Catharina, Nova Teutonia *E. aequalis* Hinton (1937).
- Disk of fourth abdominal sternite entirely tomentose. Middle tibia with antero-dorsal fringe of tomentum a fourth or slightly more than a fourth as long as tibia. Male without a ventral brush of long, golden hairs on tarsi; hind tibia with a short oblique brush of long tomentum on apex of postero-ventral margin. S. Catharina, Nova Teutonia . . . *E. codrus* sp. n.

***Elsianus isus* sp. n. (figs. 2, 4-8).**

Male: Length, 4.0-4.9 mm.; breadth, 1.6-1.8 mm. Cuticle shining and black with antennae, mouth-parts, and tarsi rufo-piceous; tibiae, femora, and trochanters nearly always also rufo-piceous. *Head* densely, microscopically punctate and also with round granules which are distinctly finer than facets of eyes and are separated by two to four diameters; on sides above eyes these granules are long, narrow, and much denser. Clypeus with anterior margin rounded at middle and very shallowly, arcuately sinuate on each side; surface with granules distinctly coarser and denser than those of head and the microscopic punctures between them much sparser and less evident than on head. Labrum with anterior margin, when seen from front, shallowly and arcuately emarginate; surface of middle region with numerous golden-testaceous hairs, which are longer than labrum; surface of middle third with a belt of dense, microscopic punctures and also with numerous fine round granules on caudal part of this punctate belt. *Pronotum* across broadest point, which is at about basal third, broader than long (1.3 mm. : 1.2 mm.) and base broader than apex (1.1 mm. : 0.92 mm.). Sublateral carina moderately broad, moderately prominent, extending from base to about apical fifth, with inner or dorso-mesal margin sharp (particularly on basal half), and at basal two-fifths or slightly before this point feebly depressed and sinuate; median longitudinal impression narrow, very shallow, indistinct, and extending from near base to about apical fourth. Surface of disk sculptured like middle of head but with both microscopic punctures and granules slightly coarser, the granules being sometimes irregular in outline and flat-topped; towards sides the granules become more obviously flat-topped, but some specimens have no flat-topped granules on the disk between sublateral carinae; sides between sublateral carinae and lateral margins with granules very convex, not flat-topped, denser, and the surface between them much less densely punctate. *Elytra* with apices (fig. 2) strongly produced and each apex separately rounded. Surface with

numerous scarcely visible (mag. $\times 75$) setae between the usual semi-recumbent hairs. Intervals flat or nearly so, but discal intervals very feebly convex on basal region; surface of intervals with round to irregularly shaped, often flat-topped granules which are half again to twice as coarse as those of middle of pronotal disk and are nearly contiguous to separated by three or more diameters; from about basal third of middle towards apex the granules become sparser and finer and on apical third are often altogether absent on discal intervals; surface between granules of basal region feebly rugulose and often with numerous microscopic punctures which, however, are finer, sparser, and much less evident than



FIGS. 4-8.—*Elsianus isus* sp. n. (4) Left lateral view of male genitalia. (5) Dorsal view of same. (6) Left lateral view of median lobe. (7) Ventral view of left paramere. (8) Inner view of apex of hind tibia.

those of pronotum. Discal striae moderately strongly impressed and punctures of first two striae on basal half deep, more or less round, one-third to one-half as broad as intervals, and usually separated longitudinally by one to two diameters. *Scutellum* longer than broad (0.22 mm. : 0.16 mm.), moderately strongly convex, and surface of caudal six-sevenths granulate like adjacent elytral intervals but more densely so. *Prosternum* with anterior two-thirds to four-fifths (not including process) gradually and moderately strongly bent ventrally; lateral prosternal carinae entirely absent. *Metasternum* with entire discal region non-tomentose and with a shallow, oval depression on each side of disk slightly

nearer hind than middle coxae. Abdomen with disk of first sternite strongly depressed, non-tomentose, and with sublateral discal carina on each side strongly and very broadly raised to hind margin of first segment. Disk of sternites two and three non-tomentose and somewhat flattened. Disk of fourth sternite with anterior half or two-thirds of middle non-tomentose. Disk of fifth sternite non-tomentose, with a very broad and shallow median longitudinal impression, and with sides of disk and apical margin of segment moderately densely clothed with long, golden hairs. Legs with a single longitudinal fringe of tomentum on front and hind tibiae and two apical fringes on middle tibia; front tibia with fringe of tomentum extending only slightly beyond basal fourth, and middle tibia with antero-dorsal fringe extending only to basal three-fifths. Hind tibia with inner or posterior spur (fig. 8) more than twice as broad as outer spur.

Female: Externally similar to male except as follows: (1) labrum with anterior margin truncate or nearly so; (2) golden hairs of labrum always much shorter than labrum; (3) metasternum with oval depression on each side of disk absent or scarcely noticeable instead of distinct; (4) sides of metasternal disk tomentose including area of the scarcely noticeable oval depression; (5) disk of first abdominal sternite less strongly depressed; (6) fifth abdominal sternite not depressed and without long golden hairs; and (7) inner spur of hind tibia only very slightly broader than outer spur.

Type: A male in the collection of the British Museum (Nat. Hist.). BRAZIL: Santa Catharina, Nova Teutonia, iii.1936 (*F. Plaumann*).

Paratypes: 17 ♂ and 12 ♀ with same data as type.

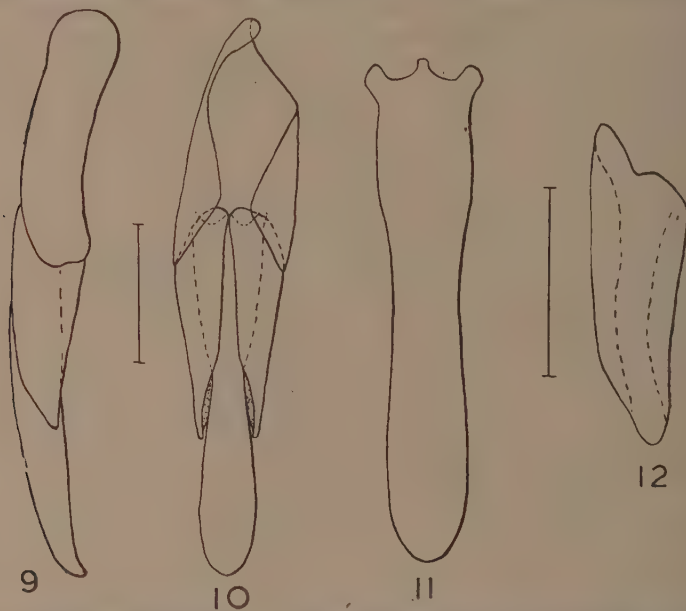
Variations: Apart from the variations already mentioned, it should be noted that the female occasionally has the disk of the first abdominal sternite as deeply depressed as the male. One female and five males have a very fine, low, median longitudinal carina on the caudal fifth of the disk of the first abdominal sternite.

Comparative notes: This belongs to a small group of species which includes *E. tarsalis* Hint. (1936) of Costa Rica and *E. clypeatus* Hint. (1936) of Trinidad, B.W.I. This species-group is characterised by having the apices of the elytra dehiscent, each elytron being separately rounded at extreme apex, and by the unusual (for *Elsianus*) secondary sexual characters of the male. The males have numerous very long testaceous hairs on the labrum, numerous long golden hairs on the fifth abdominal sternite, and the inner spur of the hind tibia is always very broadly dilated and sometimes also strongly curved. *E. isus* is much the largest of the three species, *E. clypeatus* being 3.5 mm. or less and *E. tarsalis* less than 3.0 mm. The male of *E. isus* has not the impunctate basal area of the fifth abdominal sternite of *E. clypeatus* nor the spine present on the ventral apex of the basal segment of the middle tarsus in *E. tarsalis*.

***Elsianus thorpei* sp. n. (figs. 9-12).**

Male: Length, 3.0-3.8 mm.; breadth, 1.37-1.56 mm. Cuticle very feebly shining and black with antennae, mouth-parts, and legs except coxae rufo-piceous; some specimens, which do not appear to be immature, are everywhere moderately dark rufo-piceous except for the eyes, which are black. Head with round granules which are slightly finer than facets of eyes and are usually separated by two to three diameters; surface between granules densely and microscopically punctate. Clypeus with anterior margin very shallowly, arcuately emarginate for its entire breadth; surface sculptured like head but with both granules and microscopic punctures sparser and less evident. Labrum with anterior margin, when seen from front, moderately shallowly and arcuately emarginate at middle; surface very finely and moderately densely punctate. Pronotum across broadest point, which is at about basal two-fifths, broader than long (1.15 mm. : 0.98 mm.) and base broader

than apex (1.02 mm. : 0.74 mm.). Sublateral carina very fine, low, indistinct, usually shorter than scutellum, and in some specimens with inner or dorso-mesal margin sharp but in others without a distinct inner margin; sublateral carina barely represented up to apical fourth by a slightly greater convexity of the side of the pronotum, this more convex area being completely interrupted at basal two-fifths. Disk without trace of a median longitudinal impression but with a small, oval, punctiform depression near base on each side of scutellum. Surface sculptured like middle of head but with granules very slightly coarser; granules at sides near lateral margins distinctly coarser than those of disk. *Elytra* with apices broadly, moderately strongly produced and broadly, conjointly rounded or nearly truncate. Surface, like that of pronotum, densely clothed with distinct (mag. $\times 75$) but very minute testaceous setae between the usual longer and suberect hairs. Intervals flat or nearly so except discal intervals which are very feebly convex on basal region; sur-



FIGS. 9-12.—*Elsianus thorpei* sp. n. (9) Right lateral view of male genitalia. (10) Dorsal view of same. (11) Dorsal view of median lobe. (12) Lateral view of right paramere.

face of basal discal intervals sculptured like pronotal disk but towards apex the granules become distinctly sparser. Discal striae feebly impressed and punctures of first two striae on middle a fourth or third as broad as intervals and separated by two to four diameters. *Scutellum* obovate, longer than broad (0.22 mm. : 0.15 mm.), very strongly convex, particularly caudally, and surface punctate and granulate like adjacent parts of elytral intervals. *Prosternum* with anterior half, two-thirds, or sometimes entire prosternum (not including process) gradually and moderately strongly bent ventrally; lateral prosternal carinae or ridges absent. *Metasternum* with disk entirely tomentose and central part of disk feebly depressed. *Abdomen* with disk of first sternite strongly declivous to middle or, in some specimens, anterior fourth, surface nearly entirely tomentose, and sublateral discal carinae absent. Sternites two to five entirely tomentose. Fifth sternite not depressed. *Legs* with a single longitudinal apical fringe of tomentum on front tibia and two apical fringes on middle and hind tibia; front tibia with fringe extending only to basal two-fifths; middle

tibia with antero-dorsal fringe (the shorter of the two) confined to apical fifth; hind tibia with antero-ventral fringe close and parallel to long fringe, very narrow, and only slightly longer than tibia is broad.

Female: Externally similar to male.

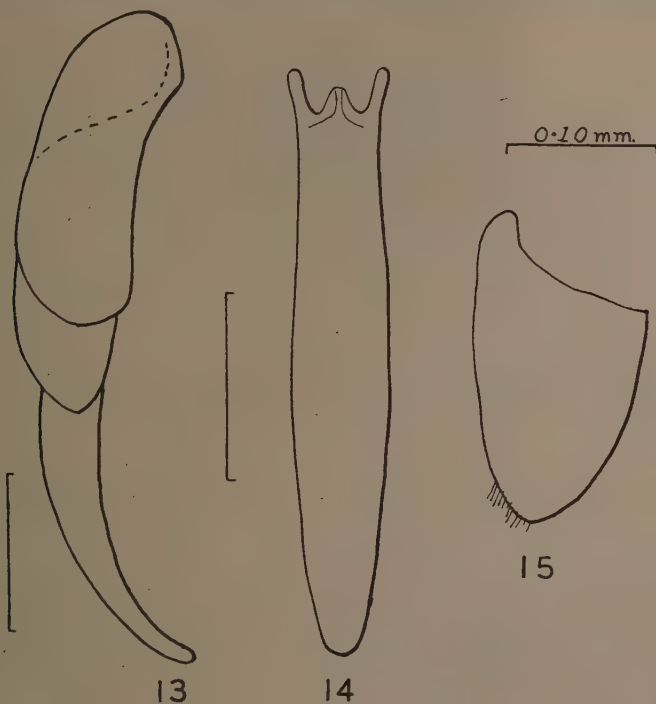
Type: A male in the collection of the British Museum (Nat. Hist.). BRAZIL: Amazonas, Manáos, Taruma River, 11.ix.1937 (*H. E. Hinton*).

Paratypes: 5 ♂ and 3 ♀ with same data as type. All specimens were found on logs and leaves lying in the river.

Comparative notes: This and the two following new species are alike in being small, having only poorly developed sublateral carinae on the pronotum, having the surface of the pronotum and elytra clothed with erect microscopic setae, having the entire surface of the metasternal disk tomentose, and in having two apical tomentose fringes on the hind tibiae. The males of the three species are also alike in having the parameres very much shorter than the median lobe. *E. thorpei* differs from its two near relatives as shown in the key. It is named in honour of my friend, Dr. W. H. Thorpe.

***Elsianus tityrus* sp. n. (figs. 13-15).**

Male: Length, 2.8-3.2 mm.; breadth, 1.3-1.5 mm. Externally similar to *E. thorpei* except in the following particulars: (1) pronotum, when seen from front, with a broad,



FIGS. 13-15.—*Elsianus tityrus* sp. n. (13) Right lateral view of male genitalia. (14) Dorsal view of median lobe. (15) Lateral view of right paramere.

transverse, moderately deep but not very distinct depression more or less parallel to extreme side of apical margin, whereas in *E. thorpei* there is no trace of such a depression; (2) sub-lateral carinae present on basal third and very distinct though only feebly elevated, the dorso-mesal margin being sharp and the sulcus mesal to the carina being rather deep; (3) the scutellum is only moderately instead of very strongly convex, and it is as broad as long instead of distinctly longer than broad; (4) lateral prosternal carinae are present on basal third or two-fifths though they are rather indistinct; (5) the anterior two-thirds or so of the prosternum is abruptly instead of only gradually bent ventrally; (6) the median area of the disk of the first abdominal sternite is non-tomentose and there is usually a small non-tomentose anterior area on the disk of the second abdominal sternite; (7) granules of disk of fourth abdominal sternite are elongate and much finer than facets of eyes, whereas in *E. thorpei* they are broadly oval or round and are as coarse as facets of eyes; (8) front tibia with fringe of tomentum extending to basal fourth or fifth instead of only to basal two-fifths; (9) middle tibia with antero-dorsal fringe of tomentum two-fifths instead of only one-fifth as long as tibia; and (10) hind tibia with antero-ventral fringe of tomentum twice as long as tibia is broad.

Female: Externally similar to male.

Type: A male in the collection of the British Museum (Nat. Hist.).
 BRAZIL: Amazonas, Manáos, Taruma River, 11.ix.1937 (*H. E. Hinton*).

Paratypes: 1 ♂ and 2 ♀ with same data as type and 4 ♀ at Manaos, Puente de Bolivia, 12.ix.1937 (*H. E. Hinton*). All specimens were found on logs and leaves lying in the two small rivers.

Elsianus tereus sp. n. (figs. 16-20).

Male: Length, 3.4 mm.; breadth, 1.5 mm. Externally similar to male of *E. tityrus*, from which it can be satisfactorily distinguished only by the structure of the genitalia. The anterior half of the prosternum (not including process) is only gradually and moderately feebly bent ventrally in the two specimens before me, whereas in all those of *E. tityrus* it is abruptly and more strongly bent ventrally. But it is unlikely that this character will prove to be sufficiently discontinuous to serve to distinguish satisfactorily long series of both species. The genitalia of both males is the same, and they differ from those of the two known males of *E. tityrus* in having the median lobe much more strongly inflated (see figures).

Female: Unknown.

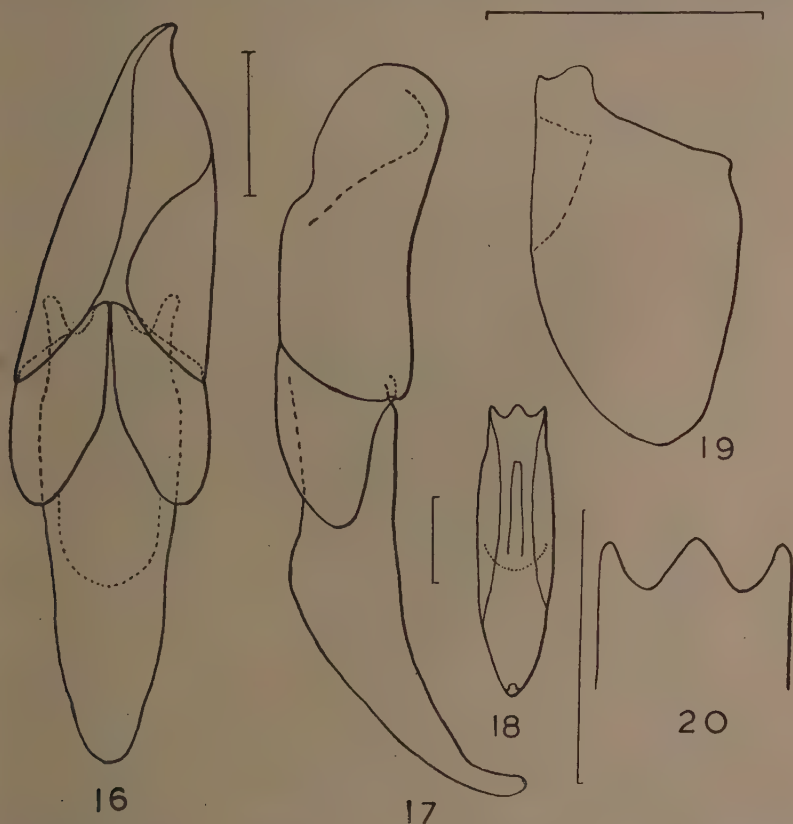
Type: A male in the collection of the British Museum (Nat. Hist.). FRENCH GUIANA: St. Laurent du Maroni, x.1937 (*H. E. Hinton*).

Paratype: 1 ♂ with same data as type.

Elsianus aristaeus sp. n. (figs. 21-23).

Male: Length, 4.5-4.8 mm.; breadth, 1.9-2.1 mm. Cuticle strongly shining and black with antennae, mouth-parts, and tarsi rufo-piceous; remainder of legs darker rufo-piceous. *Head* with round granules which are only one-half to two-thirds as coarse as facets of eyes and are usually separated by three to five diameters; surface between granules smooth or with a few microscopic punctures; extreme sides above bases of antennae without granules but with punctures as large as frontal granules and separated by one to two diameters. Clypeus with anterior margin truncate or scarcely noticeably, arcuately emarginate for its entire breadth; surface with granules less distinct and less raised than those of head and each on caudal margin of a shallow and indistinct (mag. $\times 75$) puncture, the surface in some lights appearing densely rugulose. Labrum with anterior margin, when seen from front, broadly, truncately, moderately deeply emarginate, the angle on each side of this

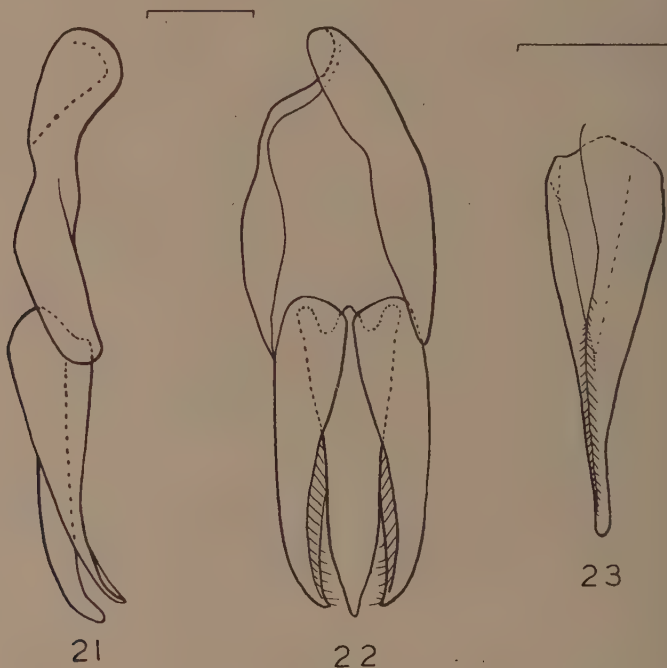
rectangular emargination being produced into a distinct tooth; surface with fine and microscopic punctures moderately densely intermixed. *Pronotum* across broadest point, which is at about middle, broader than long (1.48 mm. : 1.34 mm.) and base broader than apex (1.34 mm. : 0.93 mm.). Sublateral carina confined to basal two-fifths, low, very fine, and with inner margin sharp. Disk without trace of a median longitudinal impression. Surface of middle of disk with shallow, round or irregularly shaped punctures which are slightly finer than facets of eyes and are separated by three to five diameters; surface between



FIGS. 16-20.—*Elsianus tereus* sp. n. (16) Dorsal view of male genitalia. (17) Right lateral view of same. (18) Ventral view of median lobe. (19) Lateral view of right paramere. (20) Dorsal view of base of median lobe.

these discal punctures with an occasional microscopic puncture; on basal third at middle and on basal half near sublateral carinae with punctures replaced by fine, round granules; side with a broad belt near lateral margin with granules as coarse as, to slightly coarser than, facets of eyes and separated by one to two or, occasionally, more than two diameters. *Elytra* with apices broadly, strongly produced and conjointly very broadly rounded or nearly truncate. Surface without visible (mag. $\times 75$) setae between the usual subrecumbent hairs. Intervals flat or nearly so; surface of discal intervals sparsely, microscopically

punctate except on basal sixth or seventh where there are numerous granules as coarse as those near lateral margin of pronotum. Discal striae very feebly impressed except on basal sixth; punctures of first two striae on middle of disk deep, round (often appearing subquadrate), one-third to one-half as broad as intervals, and separated longitudinally by one to two diameters. *Scutellum* moderately strongly convex caudally, broadly obovate (0.24 mm. : 0.19 mm.), and surface with a few indistinct granules. *Prosternum* with anterior two-fifths (not including process) moderately abruptly and strongly bent ventrally; lateral carinae or ridges absent. *Metasternum* with centre of disk moderately deeply depressed and surface sub-granulate, *i.e.*, without distinct granules but with large, flat-topped, very feebly raised callosities which are contiguous or nearly so; disk also with an occasional



FIGS. 21-23.—*Elsianus aristaeus* sp. n. (21) Lateral view of right side of male genitalia. (22) Dorsal view of same. (23) Inner or mesal view of left paramere.

coarse puncture. *Abdomen* with disk of first sternite deeply and broadly depressed, non-tomentose, very finely punctate, and ridge on each side very broad, extending to caudal margin but not carinate. Second sternite with anterior middle of disk non-tomentose and with a fine, low, short, median longitudinal, basal ridge (this ridge will probably be absent in some specimens—judging by analogy with other species where such a ridge is found on the first sternite). Sternites three to five entirely tomentose; fifth with a deep, oval depression about one-fourth as long as fifth sternite, this depression, which is on the middle apex of the sternite, is declivous caudally and its caudal margin is the caudal margin of the sternite. *Legs* with a single apical longitudinal fringe of tomentum on front tibia and two apical fringes on middle and hind tibiae. Front tibia with fringe extending to basal fourth. Middle tibia with antero-dorsal fringe not quite extending to basal half.

Hind tibia with antero-ventral fringe very narrow, parallel to long fringe to which it is nearly contiguous, and about twice as long as tibia is broad.

Female : Unknown.

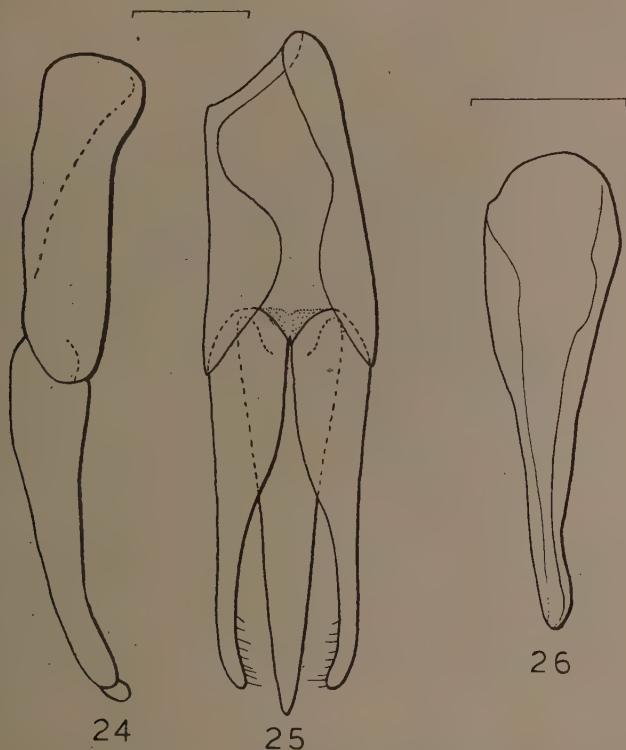
Type : A male in the collection of the British Museum (Nat. Hist.). BRAZIL : Santa Catharina, Nova Teutonia, iii.1936 (*F. Plaumann*).

Paratype : 1 ♂ with same data as type.

Comparative notes : This is very closely related to *E. amannus*, and the differences between the two are given under the heading of the latter.

***Elsianus amannus* sp. n. (figs. 24-26).**

Male : Length, 5.0-5.3 mm.; breadth, 2.2-2.4 mm. Closely related to *E. aristaeus* as regards both external structures and the form of the male genitalia (see figs.). It may be distinguished from the latter as follows : (1) head without granules, and the round to



FIGS. 24-26.—*Elsianus amannus* sp. n. (24) Lateral view of right side of male genitalia. (25) Dorsal view of same. (26) Mesal or inner view of left paramere.

elongate punctures very dense before anterior margin and on sides above eyes so that surface of these areas is rugulose; (2) clypeus without granules; (3) middle anterior margin of labrum, when seen from front, very shallowly and more or less truncately emarginate but with angle on each side broadly rounded, not toothed; (4) pronotum with sublateral

carina usually confined to basal third but in some specimens traceable to apical third as a very fine line; (5) basal region of pronotal disk sparsely and microscopically punctate, without granules; (6) lateral margins of pronotum much thickened so that at middle they are as broad as third antennal segment is long, whereas in *E. aristaeus* they are much narrower and their breadth is equal to half or less than half of length of third antennal segment; (7) scutellum relatively broader and only sparsely punctate; (8) prosternal process very nearly as broad as a front coxa instead of distinctly narrower; (9) metasternal disk finely, sparsely punctate instead of subgranulate and on anterior third broadly, transversely, and moderately strongly gibbous; (10) disk of first abdominal sternite non-tomentose but not depressed and without a sublateral ridge or carina; and (11) fifth abdominal sternite with only a scarcely noticeable depression on middle of extreme apex.

Female: Externally similar to male but with area immediately before apical margin of fifth abdominal sternite flattened instead of feebly gibbous. The very shallow median depression on the apex of the fifth sternite is slightly more distinct than that of the male.

Type: A male in the collection of the British Museum (Nat. Hist.). BRAZIL: Santa Catharina, Nova Teutonia, iii.1936 (*F. Plarumann*).

Paratypes: 3 ♂ and 7 ♀ with same data as type.

Elsianus aleus sp. n. (figs. 27-28).

Male: Length, 5.5 mm.; breadth, 2.3 mm. Externally very similar to both *E. aristaeus* and *E. amarus*. In most structural features it is nearest to the latter, but like *E. aristaeus* the head is granulate and the fifth abdominal sternite has a deep and broad apical depression. The structure of the male genitalia, however, is so different from that of *E. aristaeus* and *E. amarus* that it may be correct to assume that the external resemblance of *E. aleus* to these species is merely due to convergence and does not indicate a close genetic relationship. Its chief distinguishing features are as follows: *Head* with low, oval to round granules which are slightly but distinctly finer than facets of eyes and are usually separated by two to four diameters; region above antennal base punctate, not granulate. *Labrum* with middle anterior margin, when seen from front, not or scarcely noticeably emarginate and angle on each side broadly rounded. *Pronotum* with sublateral carina fine but distinct and confined to basal two-fifths. Lateral margins moderately strongly thickened and at basal third breadth of thickened part is equal to about two-thirds length of third antennal segment. Disk with punctures finer than facets of eyes and usually separated by two to four diameters; granules of sides lateral to sublateral carinae low, coarser than facets of eyes, and usually separated by less than one to one diameter. *Elytra* with low, flat-topped granules numerous on base and sides but absent on discal region which is more finely and sparsely punctate than pronotum. Microscopic setae absent (mag. $\times 75$) between the usual subrecumbent hairs. *Scutellum* broadly oval, moderately strongly convex caudally, and surface finely, sparsely punctate. *Prosternum* (not including process) nearly straight, the anterior half being only very feebly bent ventrally; process two-thirds as broad as front coxa and finely, very sparsely punctate. *Metasternal disk* only feebly depressed and surface with punctures as fine as those of elytral disk and usually separated by about 10 diameters; surface also with two coarse punctures on each side of disk. *Abdomen* with disk of first sternite flattened, very feebly depressed anteriorly, non-tomentose, without lateral ridges or carinae, and surface sparsely punctate like metasternal disk; middle anterior two-thirds of disk of second sternite non-tomentose and punctate like disk of first; fifth sternite with a very broad and deep, transversely oval, apical depression, the surface of which is finely punctate and non-tomentose; sternites elsewhere tomentose and granulate. *Legs* slightly stouter than those of *E. amarus* but tibiae with similar tomentose fringes.

Female: Externally similar to male but with only a very shallow depression on apex of fifth abdominal sternite. In the single female available there are numerous microscopic

punctures between the fine punctures of the pronotal disk, and these microscopic punctures become very much denser towards sides of disk.

Type: A male in the collection of the British Museum (Nat. Hist.).
 BRAZIL: Santa Catharina, Nova Teutonia, iii.1936 (*F. Plaumann*).

Paratype: 1 ♀ with same data as type.

The latero-dorsal and dorsal part of each paramere is concealed beneath a



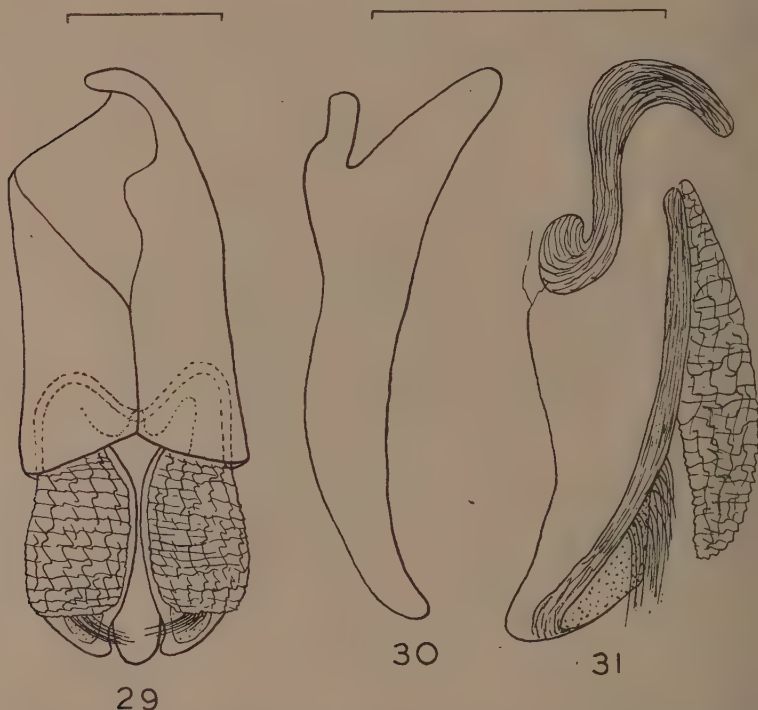
FIGS. 27-28.—*Elsianus aleus* sp. n. (27) Lateral view of right side of male genitalia. (28) Dorsal view of same with spongy layer over parameres removed.

spongy layer of tissue apparently attached near the base of the paramere as shown in figs. 29 and 31. In the only male of this species, this layer was destroyed before it was evident that it was not simply extraneous matter, and it is therefore not shown in figs. 27-28.

***Elsianus aeolus* sp. n. (figs. 29-31).**

Male: Length, 4.4 mm.; breadth, 2.0 mm. Externally rather similar to *E. aristaeus*, *E. amanus*, and *E. aleus*, from all of which it may be distinguished by having the sublateral pronotal carinae moderately prominent and extending to apical fourth and by having fine, low, round granules instead of punctures of the middle of the pronotal disk. The structure of the male genitalia (figs. 29-31) makes it appear probable that it is not closely related to the first two species mentioned but is, on the other hand, closely related to *E. aleus*.

E. aeolus and *E. aleus* are the only two species of *Elsianus* so far known which have a spongy dorsal cover on the parameres. From *E. aleus* it differs as follows: (1) sublateral carinae moderately broadly and prominently raised, extending from base to slightly beyond apical fourth, inner or dorso-mesal margin sharp, and not interrupted or depressed at basal two-fifths of pronotum; (2) middle of pronotal disk with low, round granules which are only one-half to two-thirds as coarse as facets of eyes, are usually separated by four to six diameters, and the surface between them has a few microscopic punctures; (3) scutellum more feebly convex and surface with numerous low, indistinct granules; (4) prosternal process shallowly concave between coxae and in some specimens subgranulate; (5) metasternal disk with punctures about twice as coarse as those of elytral disk, separated by two to four diameters



FIGS. 29-31.—*Elsianus aeolus* sp. n. (29) Dorsal view of male genitalia. (30) Lateral view of right side of median lobe. (31) Inner or mesal view of right paramere.

but near median line denser, subrugose and near caudal margin the surface is densely set with very low, coarse, flat-topped callosities; (6) disk of first sternite broadly and distinctly but shallowly depressed; and (7) apical depression of fifth abdominal sternite as broadly but slightly more shallowly depressed than in *E. aleus*.

Female: A single female before me with same data as males may belong to this species. It has no granules on the middle of the pronotal disk, but this condition may be due to excessive rubbing. Apart from this, it differs from the males chiefly in having a narrower and very shallow instead of moderately deep depression on the apex of fifth abdominal sternite.

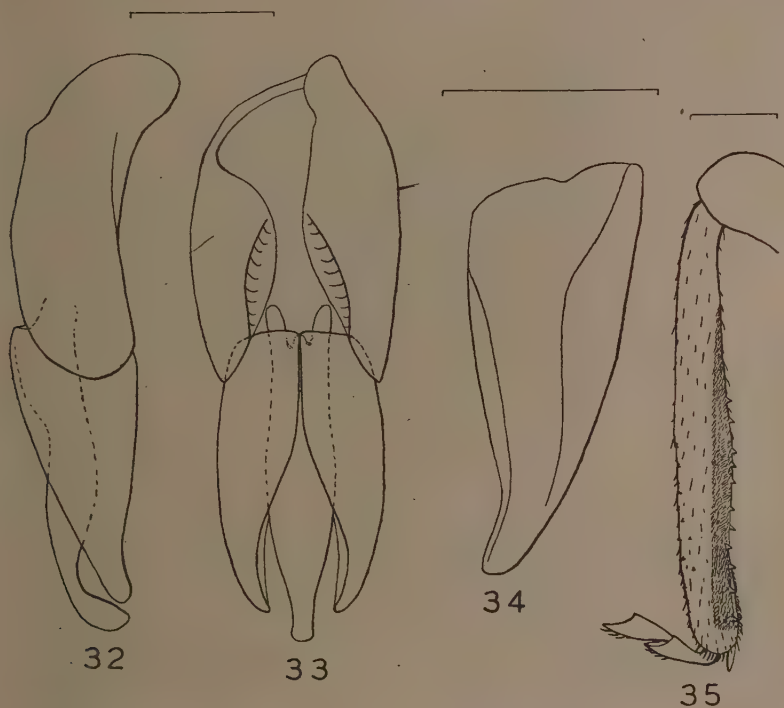
Type: A male in the collection of the British Museum (Nat. Hist.).
 BRAZIL: Santa Catharina, Nova Teutonia, iii.1936 (*F. Plaumann*).

Paratypes: 2 ♂ with same data as type.

Variations: The two male paratypes have the entire metasternal disk densely set with coarse, oval, very low, flat-topped callosities, and the fine punctures so conspicuous in the type are nearly absent in both specimens. The fine granules on the middle of the pronotal disk are easily rubbed off and when this occurs a fine puncture is left beneath each.

***Elsianus zamus* sp. n. (figs. 3, 32-35).**

Male: Length, 3.0-4.0 mm.; breadth, 1.3-1.5 mm. Cuticle shining and black with antennae, mouth-parts, and legs rufo-piceous; legs slightly more reddish than antennae and mouth-parts. *Head* with round granules which are about two-thirds as coarse as facets



FIGS. 32-35.—*Elsianus zamus* sp. n. (32) Lateral view of right side of male genitalia. (33) Dorsal view of same. (34) Ventro-mesal view of right paramere. (35) Inner or postero-ventral view of left hind tibia of male.

of eyes and are separated by two to four diameters; surface between granules with smooth and also densely, microscopically punctate areas; surface immediately above antennal bases more coarsely punctate and without granules. Clypeus with anterior margin shallowly and arcuately emarginate for its entire breadth; surface with granules less distinct, less round, and, except at base, finer than those of head, but near anterior margin with punctures

replacing granules; surface between these coarse punctures and granules nearly smooth. Labrum with anterior margin, when seen from front, very shallowly emarginate and angle on each side broadly rounded but distinct; surface of middle region with punctures as coarse as those near anterior margin of clypeus but denser. *Pronotum* across broadest point, which is at about basal third or two-fifths, broader than long (1.19 mm. : 1.15 mm.) and base broader than apex (1.09 mm. : 0.79 mm.). Sublateral carina confined to basal two-fifths, low but distinct because of the moderately deep sulcus on its mesal side on basal third, and with inner or dorso-mesal edge sharp on basal third of pronotum; carina continued from basal two-fifths to about apical third as a broad and slightly more convex region of side of pronotum. Disk without a median longitudinal impression; surface with low, round to irregularly shaped, flat-topped granules which are usually as coarse as, to half again as coarse as, facets of eyes and are separated by less than one to two diameters; surface between granules on middle of disk densely, microscopically punctate and densely, finely rugose; middle apical fourth of disk sculptured like head; sides lateral to sublateral carinae with granules as coarse as those of middle of disk but distinctly higher and less flat-topped. *Elytra* with apices (fig. 3) broadly produced and conjointly broadly rounded. Surface with very fine, scarcely visible (mag. $\times 75$) setae between the usual subrecumbent hairs. Intervals flat or nearly so; surface of intervals with round and rather flattened granules as coarse as those of middle pronotal disk but sparser; towards apex beyond about basal third granules become much finer and sparser and on apical half or two-fifths of discal intervals the granules are replaced by fine and sparse punctures. Striae distinctly impressed (in some specimens very feebly impressed on middle but more distinctly so on base and apex); discal striae punctures in first two striae deep, round to subquadrate, nearly as broad as intervals, and separated longitudinally by about their own diameters. *Scutellum* moderately convex caudally, obovate (0.19 mm. : 0.16 mm.), and surface with low, indistinct granules. *Prosternum* with anterior half to two-thirds (not including process) moderately bent ventrally (in an occasional specimen it is bent ventrally from base of process); lateral prosternal carinae very indistinct or absent. Metasternal disk moderately broadly depressed longitudinally and tomentose to middle third. *Abdomen* with disk of first sternite moderately deeply depressed, non-tomentose, and lateral discal ridge low but broad and complete to hind margin. Second sternite with anterior two-thirds or all of disk non-tomentose. Sternites three to five entirely tomentose; fifth sternite with a very narrow and very deep apical depression. *Legs* with a single apical fringe of tomentum on front tibia and two apical fringes on middle and hind tibiae. Front tibia with tomentose fringe extending to basal fifth or sixth. Middle tibia with antero-dorsal fringe extending to basal half. Hind tibia with antero-ventral fringe very narrow, parallel to long fringe to which it is nearly contiguous, and nearly three times as long as tibia is broad. Middle and hind tibiae each with a postero-ventral row of fine, acute tubercles as shown in fig. 35.

Female: Externally similar to male but with the apical depression of the fifth abdominal sternite very much shallower and without a postero-ventral row of very distinct tubercles on middle and hind tibiae. Most females have only the extreme anterior part of the disk of the second abdominal sternite non-tomentose.

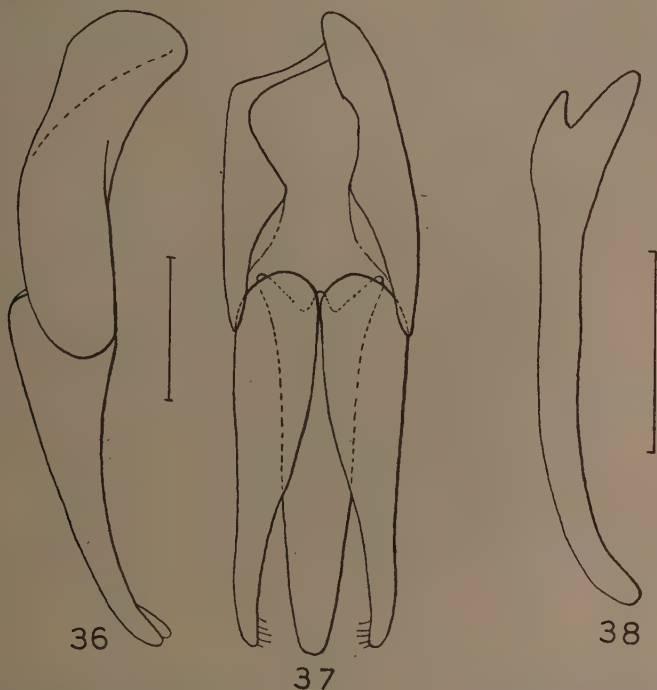
Type: A male in the collection of the British Museum (Nat. Hist.). BRAZIL: Santa Catharina, Nova Teutonia, iii.1936 (*F. Plaummann*).

Paratypes: 34 ♂ and 34 ♀ with same data as type.

Comparative notes: This is closely related to *E. plaummanni*, from which it may be distinguished as shown under the heading of that species. It is the only Brazilian species of *Elsianus* which has conspicuous postero-ventral rows of tubercles on the middle and hind tibiae of the males.

***Elsianus plaumanni* sp. n. (figs. 36-38).**

Male: Length, 4.0-4.5 mm.; breadth, 1.6-1.8 mm. Externally similar to *E. zamus* except in the following particulars: (1) granules of middle of pronotal disk are round, distinctly finer than facets of eyes and scarcely coarser than granules of head, separated by three to five or more diameters, and the surface between them is smooth or with numerous microscopic punctures but is never rugose as in *E. zamus*; (2) sublateral carina of pronotum less strongly raised and the sulcus mesal to it much shallower so that the carina is less



FIGS. 36-38.—*Elsianus plaumanni* sp. n. (36) Lateral view of right side of male genitalia. (37) Dorsal view of same. (38) Lateral view of right side of median lobe.

conspicuous than that of *E. zamus*; (3) fifth abdominal sternite moderately broadly but only very shallowly and indistinctly impressed on middle of semi-vertical part of apical margin; and (4) legs without a row of acute tubercles on postero-ventral edge of middle and hind tibiae.

Female: Externally similar to male but with middle apex of fifth abdominal sternite much flatter so that the shallow, indistinct, apical depression is nearly horizontal instead of steeply inclined.

Type: A male in the collection of the British Museum (Nat. Hist.).
BRAZIL: Santa Catharina, Nova Teutonia, iii.1936 (*F. Plaumann*).

Paratypes: 4 ♂ and 2 ♀ with same data as type.

The sides of the pronotum between the sublateral carinae and lateral margins are as coarsely granulate as those of *E. zamus*. Only the antero-median one-

fourth to two-thirds of the disk of the second abdominal sternite is free of tomentum, and none of the five males examined has a complete non-tomentose band like that of males of *E. zamus*.

***Elsianus saleius* sp. n. (figs. 39-41).**

Male: Length, 3.7 mm.; breadth, 1.4 mm. Cuticle shining and black or brownish-black with antennae, mouth-parts, legs and much of ventral surface rufo-piceous. *Head* with round granules which are about two-thirds as coarse as facets of eyes and are usually separated by two to four diameters; surface between granules with smooth as well as microscopically punctate areas. Clypeus with anterior margin nearly truncate; surface with basal region granulate less distinctly than head, the granules decreasing in size towards



FIGS. 39-41.—*Elsianus saleius* sp. n. (39) Lateral view of right side of male genitalia. (40) Dorsal view of same. (41) Dorsal view of median lobe.

apex and being often replaced by small punctures; surface between granules and small punctures smooth, not microscopically punctate. Labrum with anterior margin deeply, broadly, more or less truncately emarginate with angle on each side of emargination strongly produced and acute; surface of middle region finely and densely punctate. *Pronotum* across broadest point, which is at about basal third, no broader than long (1.12 mm.) and base broader than apex (1.06 mm. : 0.79 mm.). Sublateral carinae and median longitudinal impression absent. Middle of disk with oblong granules about as long but only about half

as broad as facets of eyes, these granules being usually separated by two to four lengths and from each granule radiate a number of fine rugae so that the surface between the granules is densely, finely rugose; anterior middle fourth of disk sculptured like head but with punctures between granules coarser. Base and sides with a fairly sharply circumscribed area of oval to oblong granules as coarse as, or slightly coarser than, facets of eyes and separated by one or two lengths; surface between these granules also finely rugose. *Elytra* with apices broadly, strongly produced and broadly, conjointly rounded. Surface apparently (mag. $\times 75$) without microscopic setae between the usual subrecumbent hairs. Intervals flat or nearly so but slightly convex before base; surface with round rather flat-topped granules as coarse as, or slightly coarser than, facets of eyes and separated by one to four diameters on basal half but towards apex on discal intervals becoming much finer and sparser. Striae strongly impressed on basal fifth, elsewhere only feebly impressed; striae punctures of first two striae on middle of disk deep, round, one-half to two-thirds as broad as intervals, and separated longitudinally by one to two diameters. *Scutellum* obovate (0.19 mm. : 0.14 mm.) and strongly convex, particularly caudally; surface finely granulate. *Prosternum* with anterior half (not including process) moderately abruptly and moderately strongly bent ventrally; lateral prosternal ridge indistinct or absent. Metasternal disk deeply, broadly, longitudinally concave and all except middle half tomentose. Abdomen with disk of first sternite very strongly depressed towards anterior margin, non-tomentose, and with lateral ridge broad, low, and complete but rather indistinct. Second sternite with middle anterior half of disk non-tomentose and slightly flattened; surface of other sternites entirely tomentose except for bottom of depression of fifth. Fifth sternite with an apical, very deep, transversely oval, very broad depression about two-thirds as long as the sternite. *Legs* with a single apical longitudinal fringe of tomentum on front tibia and two fringes on middle and hind tibiae; front tibia with fringe extending to basal fourth; middle tibia with antero-dorsal fringe extending only to basal three-fifths; hind tibia with antero-ventral fringe two-fifths as long as the tibia, moderately widely separated from the longer fringe (because of dilation of tibia at this point), and with tomentum very long. Hind tibia moderately strongly curved and dilated at apical two-fifths. Basal segment of front and middle tarsi with a broad and distinct brush of long, erect, golden-testaceous hairs on ventral apex; basal segment of hind tarsus with a similar but subrecumbent, less dense, and less distinct brush.

Female: Unknown.

Type: A male in the collection of the British Museum (Nat. Hist.). BRAZIL: Santa Catharina, Nova Teutonia, iii.1936 (*F. Plaumann*).

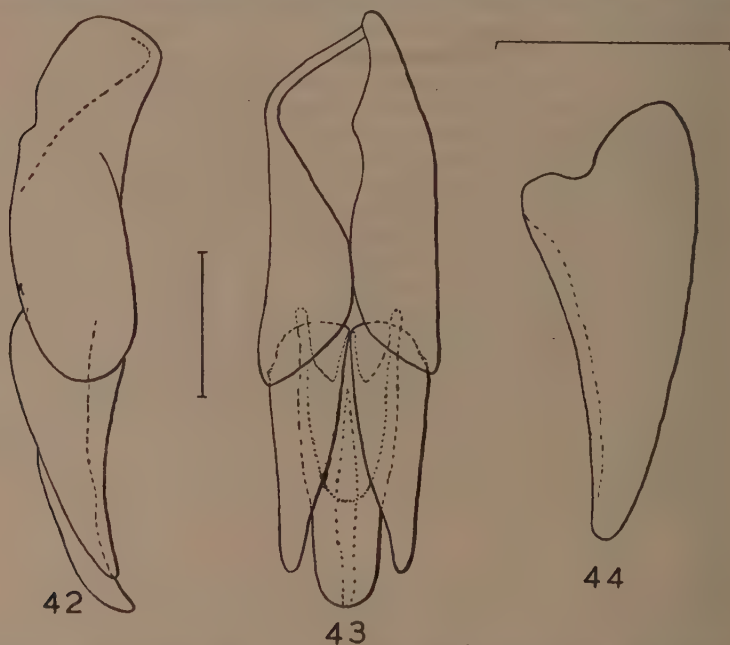
Paratype: 1 ♂ with same data as type.

Comparative notes: The structure of the genitalia (figs. 39-41) appears to confirm the moderate isolation of this species suggested by the deeply emarginate, toothed labrum and the curious dilation of the hind tibia of the male. The only other Brazilian *Elsianus* with a deeply emarginate and toothed labrum is *E. aristaeus*, which is a much larger species (4.5-4.8 mm. long) having sublateral carinae on the pronotum, a punctate instead of granulate pronotal disk, and very different male genitalia (figs. 21-23).

Elsianus celsus sp. n. (figs. 42-44).

Male: Length, 4.0-5.0 mm.; breadth, 1.7-2.1 mm. Cuticle shining and black with antennae, mouth-parts, and legs rufo-piceous. *Head* with round granules which are about two-thirds as coarse as facets of eyes and are separated by three to four diameters; surface between granules with irregularly distributed microscopic punctures which are sometimes so dense that the surface appears rugose. Clypeus with anterior margin nearly truncate; surface sculptured like head but with granules lower and much less distinct and the inter-

mixed microscopic punctures much less dense. Labrum with anterior margin, when seen from front, scarcely noticeably emarginate at middle; surface finely, densely punctate but extreme base transversely, microscopically alutaceous and extreme apex nearly smooth. *Pronotum* across broadest point, which is at about basal third or basal two-fifths, much broader than long (1.59 mm. : 1.42 mm.) and base broader than apex (1.43 mm. : 1.04 mm.). Median longitudinal impression and sublateral carinae absent (in a few specimens, including the type, a fine line about a third as long as scutellum can be seen at extreme base with a magnification of $\times 75$). Surface of middle of disk with round granules about three-fourths as coarse as facets of eyes and separated by two to four diameters; surface between granules with smooth as well as moderately sparsely, microscopically punctate areas. Surface at sides with granules as coarse as, to one-third coarser than, facets of eyes, often somewhat



FIGS. 42-44.—*Elsianus celsus* sp. n. (42) Lateral view of right side of male genitalia. (43) Dorsal view of same. (44) Outer view of left paramere.

flat-topped, and separated usually by one or slightly more than one diameter; areas between these granules usually finely rugulose and densely, microscopically punctate. *Elytra* with apices broadly, strongly produced and broadly, conjointly rounded or nearly truncate. Surface—like that of head and pronotum—with extremely fine (mag. $\times 75$) recumbent setae between the usual subrecumbent hairs. Intervals flat or nearly so; surface on base and sides of elytra granulate like sides of pronotum but more sparsely and indistinctly so and on apical four-fifths the first four intervals are more finely and much more sparsely granulate than head. Striae feebly impressed, more deeply so near base and apex; stria punctures at middle of first two striae deep, round (sometimes appearing subquadrate), one-third to two-thirds as broad as intervals, and separated longitudinally by one to two diameters. *Scutellum* obovate (0.27 mm. : 0.22 mm.), strongly convex with highest point at caudal two-fifths, and surface finely, obscurely granulate and microscopically punctate.

Prosternum, when seen from side, usually moderately strongly and gradually bent ventrally from base of process but in some specimens only anterior half (not including process) is bent ventrally; lateral prosternal ridges or carinae absent. Metasternal disk nearly flat but with median line broad and deep; surface coarsely, densely granulate and non-tomentose on middle two-thirds. *Abdomen* with disk of first sternite moderately depressed, non-tomentose, and ridge on each side broad, complete, but indistinct; second sternite with anterior third of disk very feebly but broadly and distinctly concave and with only anterior fifth non-tomentose; other sternites entirely tomentose and granulate; fifth sternite without an apical depression. *Legs* with a single apical longitudinal fringe of tomentum on front and hind tibiae (the antero-ventral fringe of hind tibia being more or less completely fused with the long postero-ventral fringe) and two fringes on middle tibia. Front tibia with fringe extending to basal tenth or beyond and middle tibia with antero-dorsal fringe extending to basal half.

Female: Externally similar to male.

Type: A male in the collection of the British Museum (Nat. Hist.).

BRAZIL: Santa Catharina, Nova Teutonia, iii.1936 (F. Plaumann).

Paratypes: 9 ♂ and 10 ♀ with same data as type.

Comparative notes: This is close to *E. aequalis* Hint. (1937) and *E. codrus* (described below), from both of which it may be distinguished by not having the fifth abdominal sternite depressed and by having the tomentose fringe of the front tibia extending very nearly to the base instead of only to the basal fourth of the tibia.

Elsianus codrus sp. n. (figs. 45-47).

Male: Length, 4.2-5.0 mm.; breadth, 1.8-2.1 mm. Externally similar to both *E. celsus* and *E. aequalis* Hint. (1937), all three species having the head and pronotum punctate and granulate as described for *E. celsus*. From *E. celsus* it may be distinguished as shown under the heading of that species, and from *E. aequalis*, to which it is even more closely related, it differs in the following particulars: (1) fourth abdominal sternite entirely tomentose instead of with anterior middle fourth of disk non-tomentose; (2) middle tibia with antero-dorsal tomentose fringe a fourth or slightly more than a fourth as long as tibia instead of a third or more as long; (3) tomentose fringe of hind tibia ending at about apical fifth but at apex with a short fringe of long hairs which is on apical part of postero-ventral margin and is slightly oblique to long axis of tibia, whereas in *E. aequalis* the tomentose fringe ends similarly at about apical fifth but there is no apical brush of tomentum and the apical fifth of the tibia is less strongly curved and dilated; (4) the basal segment of each tarsus has a few long hairs on its ventral surface, whereas in *E. aequalis* there is a thicker and more distinct brush on the ventral apex of each of the four basal segments of all tarsi, the ventral brushes of the hind tarsi being less distinct than those of the front and middle tarsi; and (5) the parameres (figs. 45-46) end some considerable distance before the apex of the median lobe instead of very nearly attaining the apex.

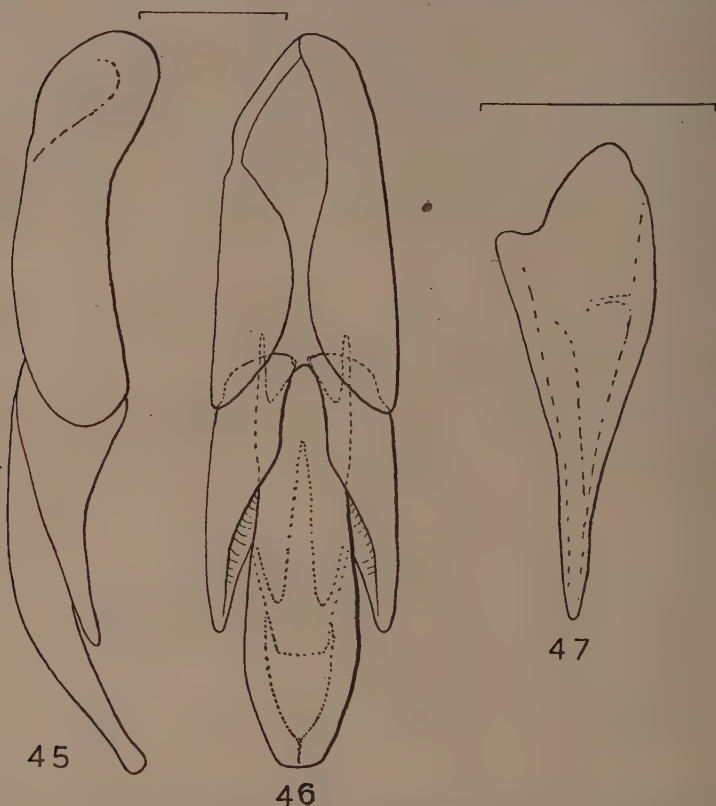
Female: Externally similar to male except as follows: (1) anterior margin of labrum more shallowly emarginate and angle on each side of emargination not so distinct; (2) apical depression of fifth abdominal sternite much shallower and narrower and the narrow transverse channel, which is so conspicuous in the male on each side of the apex of the broad depression, is absent; (3) hind tibia not noticeably curved nor dilated in apical fifth and without the short and slightly oblique apical fringe of long tomentum; and (4) tarsi usually without long hairs on the ventral apex of the basal segment.

Type: A male in the collection of the British Museum (Nat. Hist.).

BRAZIL: Santa Catharina, Nova Teutonia, iii.1936 (F. Plaumann).

Paratypes: 7 ♂ and 5 ♀ with same date as type.

In *E. celsus* the hind tibia has one or two tomentose fringes depending on the degree of fusion of the short antero-ventral fringe to the long postero-ventral



FIGS. 45-47.—*Elsianus codrus* sp. n. (45) Lateral view of right side of male genitalia. (46) Dorsal view of same. (47) Outer view of left paramere.

fringe. In *E. aequalis* and in the female of *E. codrus* there is only one fringe. In the male of *E. codrus* the slightly oblique apical fringe is postero-ventral and obviously not homologous to the antero-ventral fringe of other species.

Elsianus antiquus Grouvelle.

1896. *Elsianus antiquus* Grouvelle, *Notes Leyden Mus.* 18:41.

I have been unable to include this species in my key, as the original description is not sufficiently detailed. Apart from generalities which will apply to almost every species of the genus, it possesses the following characters:—

Length, 4 mm. Cuticle black. Head densely punctate. Pronotum with sublateral carinae very short; disk finely and sparsely punctate. Scutellum broadly oval and convex. Elytra with intervals flat and broader than stria punctures.

Type: BRAZIL. In the Paris Museum.

REFERENCES.

- GROUVELLE, A., 1889, Nouvelles espèces d'Helmides. *Ann. Soc. ent. Fr.* **8** (6) : 393-410, 2 pls. (p. 396, *E. pubescens*).
- , 1896, Descriptions des Dryopides (Parnides) et Helmides nouveaux. *Notes Leyden Mus.* **18** : 33-52 (p. 41, *E. antiquus*; p. 44, *E. granosus*).
- HINTON, H. E., 1936, Descriptions and figures of new Brazilian DRYOPIDAE (Coleoptera). *Entomologist* **69** : 283-9, 6 figs. (p. 283, *E. salti*).
- , 1937, Notes on some Brazilian POTAMOPHILINAE and ELMINAE (Coleoptera, DRYOPIDAE). *Ent. mon. Mag.* **73** : 95-100, 9 figs. (p. 97, *E. aequalis*).
- , 1940, A monographic revision of the Mexican water beetles of the family ELMIDAE. *Novit. Zool.* **42** : 217-396, 401 figs.
- , 1945, Descriptions of two new species of *Elsianus* Sharp, with a key to the graniger species-group (Col., ELMIDAE). *Ent. mon. Mag.* **81** : 90-92, 5 figs. (p. 91, *E. amazonicus*).

Vol. 96. Part 9. Pp. 151-162, 30 figs.

15th May, 1946.

COMMONWEALTH INST
ENTOMOLOGY LIBRARY

104-240

SERIAL Eu. 344
SEPARATE

THE

TRANSACTIONS

OF THE

ROYAL

ENTOMOLOGICAL SOCIETY

OF

LONDON

World List abbreviation: Trans. R. ent. Soc. Lond.

CONTENTS

	PAGE
ZAKHVATKIN, A. A., D.Sc. Notes on some Homoptera from Yemen	151-162, 30 figs.

LONDON:

PUBLISHED BY THE SOCIETY AND
SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 3s. 0d.

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Founded, 1833. Incorporated by Royal Charter, 1885.

PATRON—HIS MAJESTY THE KING.

OFFICERS and COUNCIL for the SESSION, 1946–1947.

PROF. G. D. HALE CARPENTER, M.B.E., D.M., *President*.

W. J. HALL, D.Sc.

C. B. WILLIAMS, M.A., D.Sc. } *Vice-Presidents*.

H. B. WILLIAMS, LL.D.

A. WELT, *Treasurer*.

N. D. RILEY, *Secretary*.

Other Members of Council.

C. H. ANDREWES, F.R.S.

J. W. EVANS, M.A., D.Sc.

G. FOX-WILSON, N.D.H.

R. M. GREENSLADE.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

CAPT. R. A. JACKSON, R.N.

MISS C. E. LONGFIELD.

SIR GUY A. K. MARSHALL, K.C.M.G.,

D.Sc., F.R.S.

G. E. J. NIXON, B.A.

J. F. PERKINS, B.Sc.

F. J. GRIFFIN, A.L.A., *Registrar*.

Finance and House Committee.

G. FOX-WILSON, N.D.H. (*Chairman*).

J. W. EVANS, M.A., D.Sc.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

W. RAIT-SMITH.

O. W. RICHARDS, M.A., D.Sc.

Publication and Library Committee.

W. J. HALL, D.Sc. (*Chairman*).

H. E. HINTON, B.Sc., Ph.D.

B. M. HOBBY, M.A., D.Phil.

J. F. PERKINS, B.Sc.

J. SMART, B.Sc., Ph.D.

W. H. THORPE, M.A., Sc.D.

Committee on Generic Nomenclature.

FRANCIS HEMMING, C.M.G., C.B.E. (*Chairman*).

W. A. F. BALFOUR-BROWNE, F.R.S.E.

K. G. BLAIR, D.Sc.

O. W. RICHARDS, M.A., D.Sc.

N. D. RILEY (*Secretary*).

Committee for the Protection of British Insects.

H. M. EDELSTEN, O.B.E. (*Chairman*).

R. B. BENSON, M.A.

E. A. COCKAYNE, M.A., M.D., F.R.C.P.

CAPT. R. A. JACKSON, R.N.

COL. F. A. LABOUCHERE.

A. M. MASSEE, D.Sc.

THE HON. MIRIAM ROTHSCHILD.

W. H. THORPE, M.A., Sc.D.

N. D. RILEY (*Secretary*).

The Executive Officers of the Society are *ex-officio* members of all Committees.

DELEGATES OF THE SOCIETY TO :

1. British National Committee for Biology (Royal Society).

Mr. Francis Hemming, C.M.G., C.B.E., appointed 1945.

Dr. V. B. Wigglesworth, M.A., B.Ch., M.D., F.R.S., appointed 1943.

2. Local Committee of Management of Wicken Fen.

Mr. H. M. Edelsten, O.B.E. [nominated by Committee for the Protection of British Insects].

3. National Trust for Places of Historic Interest or Natural Beauty.

Mr. H. M. Edelsten, O.B.E., appointed 1944.

4. New Forest Association.

Mr. W. Fassnidge, appointed 1934.

5. New Forest Joint Committee.

Mr. W. Fassnidge, appointed 1939. Dr. F. J. Killington, D.Sc., A.L.S., appointed 1939.

6. Royal Meteorological Society. Phenological Committee.

Dr. C. B. Williams, M.A., D.Sc., appointed 1937.

7. Biology War Committee.

Prof. P. A. Buxton, M.A., F.R.S., appointed 1941.

8. Council for the Promotion of Field Studies.

Dr. W. H. Thorpe, M.A., Sc.D., appointed 1944.

9. Joint Bioclimatic Committee.

Dr. B. P. Uvarov, C.M.G., D.Sc., appointed 1945.

Dr. C. B. Williams, M.A., D.Sc., appointed 1945.

247
NOTES ON SOME HOMOPTERA FROM YEMEN

By A. A. ZAKHVATKIN, D.Sc.

(Zoological Institute, University of Moscow.)

Communicated by Mr. W. E. China, M.A., F.R.E.S..

Manuscript received 14th February, 1945.

(Read 2nd May, 1945.)

WITH 30 TEXT-FIGURES.

In my previous note (1935, *Science Bulletin of the University of Moscow* 4 : 106-115), I have given a short and quite provisional account of a collection of Homoptera gathered by N. N. Jenjouriste in Yemen. As no further data have so far appeared on the same subject, I believe it of interest to give a more detailed description of this valuable material which has been supplemented by some further specimens forwarded to me of late. The present communication is the first of a series of notes I hope to devote to the achievement of this task.

The bulk of the material dealt with was captured at light at Hodeida, the principal port of Yemen, while a small number of insects was secured in the vicinity of Sanaa, the capital city of that country.

1. *Empoasca minor* Zakhvatkin (figs. 1-4).

1935 : *Empoasca decipiens minor* Zakhvatkin, *op. cit.* : 112.

Hodeida, 26.ix. ; 2 ♂.

Elevated from subspecific to specific rank.

A rather small species of the *flavescens* group showing close affinities to the widely spread Mediterranean *E. decipiens* Paoli 1930, but noticeably differing from it in pigmentation and certain characters of the male genitalia.

♂. General colour light yellowish suffused with green, scutum and underside of a more definite honey yellow tint, vertex, pronotum and scutum with the usual obsolete white markings. Medial cell of tegmina quite colourless, as in the genuine *E. flavescens* (auct.) Ribaut 1933 (= *E. vitium* Paoli 1930) but being in a sharper contrast with the rest of corium, which is of a relatively rich yellow tinge, becoming especially deep along the cubital vein; costa and, in a lesser extent, the apical cross-veins, dark malachite green, membrana scarcely infuscated.

Lateral processes of pygophor as in *E. decipiens meridiana* A.Z. 1943, from Persia and adjacent countries, with subapical dilatation well developed but even more distinctly crenulated. Processes of the tenth segment very slender, of an almost linear shape, nearly straight; their posterior (or, morphologically speaking, dorsal) edge serrulated more than half-way to the base with the denticules very widely interspaced and nearly equidistant; the anterior edge serrulated in a similar, but rather indistinct way, or nearly smooth. Aedeagus much more slender than in any other member of the *decipiens* stock, especially in more southern forms where it is rather much expanded; with a very long and slender ventral articulating process.

Measurements. Total length, 3.10-3.12 mm.; width across eyes, 0.60-0.62 mm.; length of vertex, 0.19 mm.; inter-orbital width, 0.33-0.34 mm.; length of pronotum, 0.34 mm.; width of the same, 0.67 mm.; length of tegmina, 2.56-2.58 mm., width of tegmina, 0.55 mm.

TRANS. R. ENT. SOC. LOND. 96. PART 9. (MAY 1946.)

L

2. *Helionidia* gen. n.

Hodeida, 26-29.ix.; 1 ♂, 2 ♀.

This new genus belongs to the ZYGINAE,¹ but essentially differs from all of them in the frontal sutures much more convergent anteriorly, in the remarkable structure of the female ovipositor and many other particulars. On the other hand, *Helionidia* shows well-marked distinctness from *Heliona* and its nearest allies (*Apheliona* Kirkaldy 1907, *Helionides* Matsumura 1931) in a far lesser degree of the frontal suture convergence and a true Zyginoïd, rather generalised condition of the hind-wing venation.

The principal features of *Helionidia* may be summarised as follows: Frontal sutures strongly convergent anteriorly, but not to the same extreme degree as in *Heliona* and allies, the distance between their anterior ends being nearly equal to the width of labrum; vertex in the female sex with at least a faint tendency to assume helionoid outlines, i.e. with front margin more or less distinctly sinuate each side of middle; occiput in many cases more developed than usual in EUPTERYGIDAE, and correspondingly more overhanging the anterior edge of pronotum; face not obviously elongate. Venation of tegmina fundamentally as in *Zyginidia*, but CuA₂ much shorter than proximal (free) part of CuA; in some species, the radial vein acquires the peculiar position found in certain *Heliona* (for instance, *H. adspersa* Haupt 1927), viz. it runs in an oblique direction close to the middle of media, and thus suggests the presence on the tegmina of a nearly closed subapical cell. Hind-wings almost rectangular in general outline, with apical margin truncated and distinctly sinuated, and a typically Zyginoïd venation. Male genitalia of the *Zyginidia* type: processes of the pygophor unforked, aedeagus tubular with a pair of simple terminal but without any basal appendages; in some species the connective armature which serves to articulate it with the pygophor and the anal tube is greatly and quite originally modified. Female subgenital plate very long, strongly produced, usually with a deep median incision on the tip; coleostrom and ovipositor comparatively very short and stout, truncated posteriorly and assuming in death an unusual upright position; saws of ovipositor simply curved, instead of the normal sigmoid form, those of the inner pair of a very peculiar scimitar-like shape, with strictly localised sclerotisation and unbranched inner cavity; the outer saws very roughly squamate.

Base colour usually inclining to greenish, with a dark pattern sharply contrasted to evanescent and consisting in typical cases of two almost circular spots on vertex, a series of dots close to anterior margin of pronotum, a dark area on mesonotum and usually some more markings on various parts of the body.

Nymphs with strongly depressed body, somewhat resembling those of *Eurhadina* in general appearance, thus of a particular type, unknown in other genera of ZYGINAE; with head strongly flattened, of about the same width as pronotum and trapezium-like in general outline; and frontal sutures almost concealed anteriorly and nearly encircling the clypeofrons.

Type of the genus, *Heliona biplagiata* Haupt 1927, from Palestine.

Within the genus *Helionidia* two definite divisions are evident, to which I am according the rank of subgenera. The first of them, *Helionidia* s.str., includes comparatively stout species of decidedly xeromorphic appearance and probably xero-halophilous in their habits, having in common the following features:—

¹ As may be termed the natural group of Eupterygid genera composed by *Zyginia* Fieber 1866 (typ. gen. *Z. nivea* Fieber 1866), *Erythroneura* Fitch 1851 (typ. gen. *E. trilineata* Fitch), *Zyginidia* Haupt 1929 (typ. gen. *Z. scutellaris* Herrich-Schäffer), *Zyginella* P. Löw 1888 (typ. gen. *Z. pulchra* Löw, 1888).

Helionidia s.str.

General colour, vividly greenish-yellow with the dark pattern rather sharply contrasted and always including, besides its principal elements, a small longitudinal streak on the tip of head, a spot on labrum and, in the female, a spot on the subgenital plate. Tegmina rigid, rather coriaceous, usually helionoid in the type of venation; cross-veins of the hind-wings usually interstitial. Male genital plates with very prominent basal lobes and ventral edges conspicuously angulate in a lateral view; processes of the pygophor of various, but always very original shape; aedeagus of quite abnormal structure, with highly exaggerated dorsal apodeme, unusually heavily sclerotised and fused with the stem of aedeagus along its dorsal edge; apical part of the gonopods strongly developed, foot-shaped. Female subgenital plate with a deep median incision.

Apart from the type species, *H. biplagiata* (figs. 6, 10, 18-22), and *H. himyarita* m., a third form of the subgenus I am acquainted with occurs in the North Caspian deserts. This form, *H. statices* m., lives on a halophilous subshrub, *Statice suffruticosa* L., in an extremely arid environment.

The second subgenus of *Helionidia* includes a number of species living on *Tamarix* and previously referred to *Zygina*, *Erythroneura* or *Chlorita*, viz. *Z. jaxartensis* Oshanin 1871; *Z. tamaricis* Puton 1875; *Chl. fasciolata* (Fieber) Lethierry 1876; *Chl. biskrensis* Lethierry 1876; and some other, partially thus far, undescribed species. The features, distinguishing it from the typical subgenus, are as follows:—

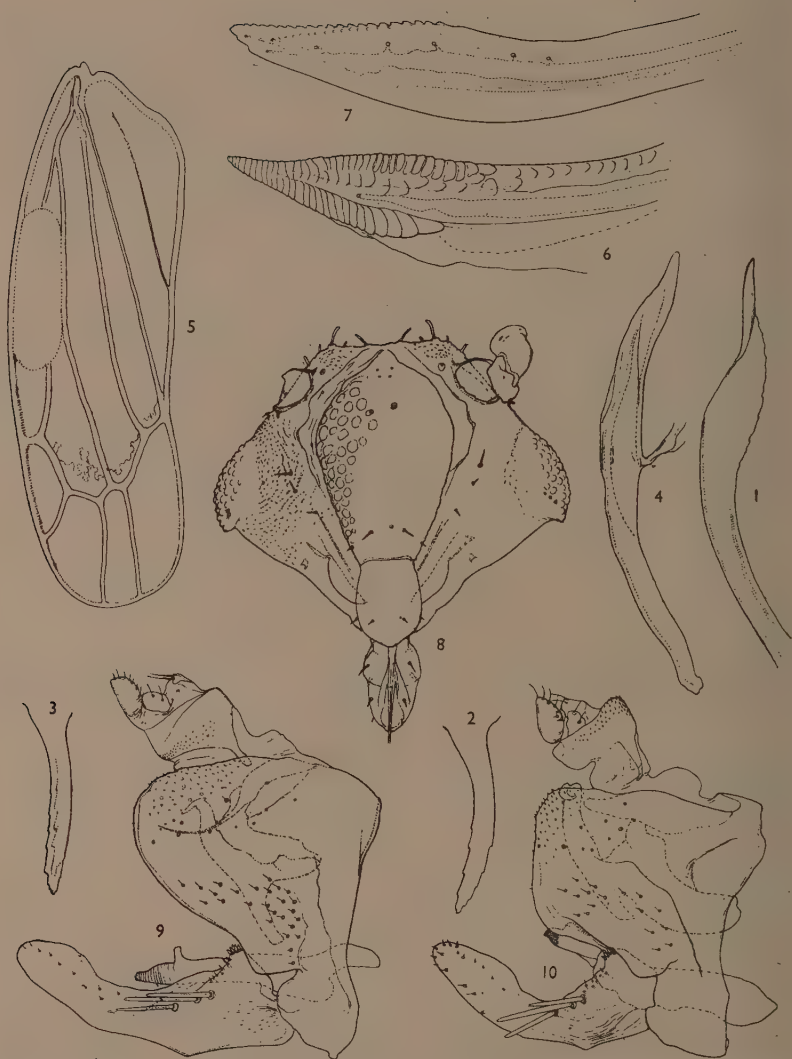
Tamaricella subgen. n.

Type of subgenus: *Zygina jaxartensis* Osh., 1871.

Rather delicate, slender, merely mesophilous forms of a somewhat olivaceous base colour, with a dark pattern rather obsolete to evanescent, lacking the above-mentioned particulars of *Helionidia* s.str., but usually including some indefinite fuscous markings on the tegmina. The latter membranaceous with venation of a purely zyginioid type; second cross-vein of the hind-wings obviously postfurcal. Male genital plates with rounded basal lobes and evenly curved lower edges; processes of the pygophor boat-hook shaped, gonopods and aedeagus of a quite ordinary structure, the latter with moderately developed dorsal apodeme and almost membranaceous connective elements. Female subgenital plate without a deep median notch.

The above statement allows *Helionidia* to be considered as occupying an intermediate position between the true ZYGINAE on the one hand, and the highly modified, very aberrant forms centring about *Heliona*, on the other. Its basic organisation is in all essentials purely zyginioid, but with the addition of some definitely helionoid features, e.g. the structure of the head, that of the female genitalia and, to a lesser extent, some particulars of the wing venation. The number of such helionoid features varies quite appreciably with each separate species of *Helionidia*, which allows them to be arranged in a row, illustrating the diverse steps of an increasing "helionisation." The most generalised representatives of *Helionidia* are undoubtedly the species of *Tamaricella*, that exhibit in an almost primitive condition many features typical of the genuine mesophilous ZYGINAE and especially to such arbusticolous forms as *Zyginiidia bisignata* Muls. R., the *Z. parvula* group, etc.

H. jaxartensis is linked to the true *Helionidia* of the *biplagiata* type by *H. statices* n., in which one finds some other helionoid characters visible; for example, in the structure of the face and the hind-wing venation (fig. 8). *H.*



FIGS. 1-10.—1, *Empoasca minor* A.Z. ♂, lateral process of pygophor; 2 and 3, process of tenth segment; 4, aedeagus, lateral view. 5, *Helionidia himyarita* sp. n. ♀, tegmen. 6, *H. biplagiata* Hpt. ♀, external saw of ovipositor; 7, internal saw of ovipositor. 8, *H. statices* sp. n., head of the full-grown nymph. 9, *H. himyarita* sp. n. ♂, lateral view of genitalia. 10, The same of *H. biplagiata* Hpt.

biplagiata and *H. himyarita* are still more helionised by the addition of such an essential feature as the highly specialised condition of the radial vein of the tegmina. Here the line of development just referred to runs rather close to some *Heliona*, viz. to the best known of all, *H. adspersa* Haupt 1927, which accordingly exhibits well-marked traces of a zyginid origin. In this species, for instance, the peculiar hind-wing venation can be easily interpreted as a modified state of the basic zyginoid type. Bearing in mind the fact that the fundamental feature of *Heliona*, the nearly closed clypeus, is found in nymphal instars of *Helionidia*,² one may actually assume *Heliona* to belong to the ZYGINAE and to represent one of their highest specialised branches. Thus the systematic position of *Helionidia* seems to have received a correct interpretation.

A species, closely allied to the Palestine *Heliona biplagiata* Haupt 1927 (*Homopt. Palest.* 1: 42, fig. 40) and forming with this and certain other species previously referred to *Erythroneura* (or *Zyginidia*, *Zygina*, etc.) a thus far undescribed separate genus, quite distinct from either *Heliona* Melichar 1903 or *Zyginidia* Haupt 1929.

***Helionidia himyarita* sp. n. (figs. 5, 9, 11–17).**

As has been already mentioned, *Helionidia* (s.str.) *himonyrita* sp. n. greatly resembles *H. biplagiata* Haupt. A careful comparison with two of the cotypes of Haupt (1 ♂ and 1 ♀) from Ben-Shemen near Ludd, 5–6.x.1925, has shown the following differences which distinguish *H. himyarita* from the Palestine species:

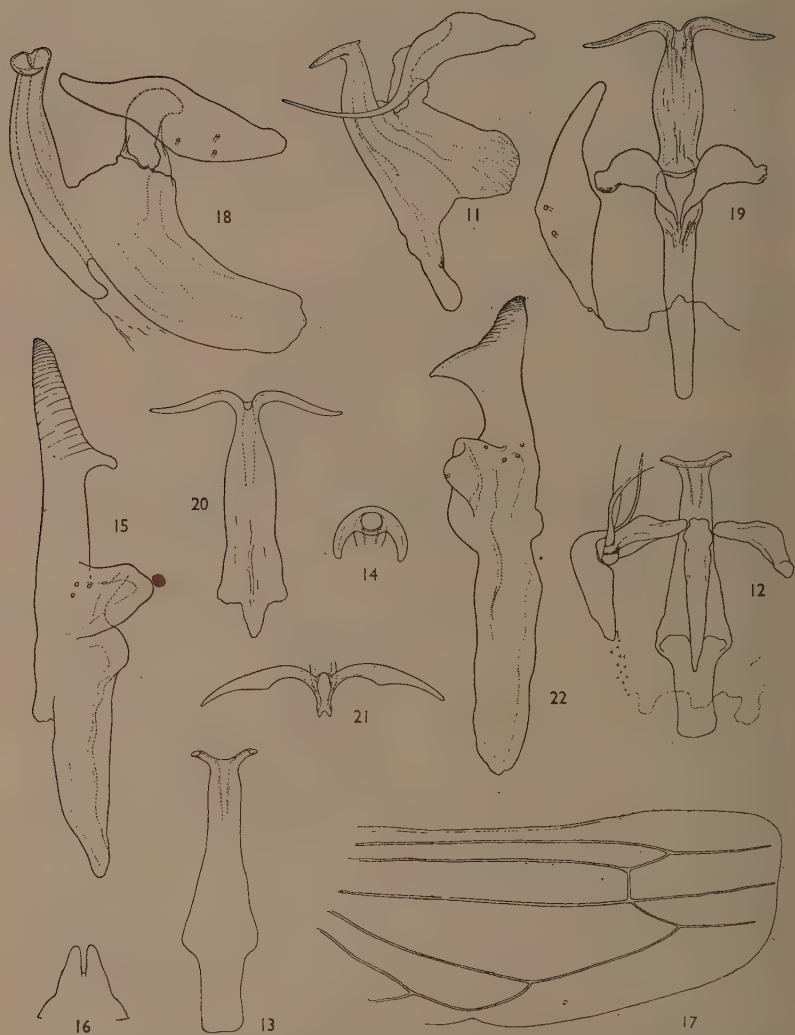
General colour lighter, decidedly more uniform and pure sulphur-yellow with dark pigmentation relatively less developed. Clypeus in the male entirely pale, in the female with fairly indistinct spurs of the brown transverse lineolation, found in *biplagiata*. Pronotum immaculate, without any traces of the six dark spots characterising the last-named species; the black area of mesonotum (which is partially covered by the pronotal shield, giving to it a marked greenish tint) has a different, almost horseshoe-like outline, as its posterior margin is distinctly more emarginate than in *biplagiata*. Membrana of tegmina scarcely suffused with fuscous, the medial apical cell practically colourless.

Size, somewhat smaller than in *biplagiata*; general proportions nearly as in the latter, only a trifle heavier and more robust; width across eyes contained (in both male and female) about 3.55 times in the total length; inter-orbital width equal to or somewhat more than the length of pronotum; tegmina 3.3 times as long as wide.

♂. Lobes of the pygophor more rounded caudally with postero-ventral edge not produced at all, and unusually slender, acicular dorsal processes. Aedeagus with stem more sharply curved and very short terminal appendages, which are fused into a crescent-shaped plate; its dorsal apodeme decidedly smaller and not so heavy, extending cephalad for a shorter distance, but more protruded in the caudal direction. Gonopods with strongly elongate apical parts of a quite characteristic shape.

♀. Subgenital plate about as long as wide at base, with lateral edges sinuately emarginate in the apical half and an unusually deep median incision running in the form of a linear slit about half-way to the base of the plate, and dividing its apical part into two narrow, linguiform, separately rounded lobes; the margins of the notch are narrowly infusate. Ovipositor as in *H. biplagiata* and the other species of *Helionidia*.

² In this case the above similarity in the structure of the head is quite complete, a fact to be ascertained by a comparison of fig. 8 with those of Haupt (fig. 38, a, b) and suggesting that in *Heliona* the highly specialised condition of the head is no more than a purely nymphal feature persisting in the adult stage.



FIGS. 11-22.—11, *Helionidia himyarita* sp. n. ♂, aedeagus and processes of tenth segment lateral view; 12, dorsal view of same; 13, aedeagus, ventral view; 14, tip of aedeagus; 15, style; 16, ♀ subgenital plate; 17, hind-wing. 18, *H. biplagiata* Hpt. ♂, aedeagus and processes of tenth segment, lateral view; 19, dorsal view of same; 20, aedeagus, ventral view; 21, tip of aedeagus; 22, style.

The measurements are shown in the following table, where those of the two cotypes of *H. biplagiata* are given for comparison.

Name and sex	Total length	Width across eyes	Length of vertex	Inter-orbit. width	Length of pronotum	Posterior width of pronotum	Length of tegmina	Width of tegmina
<i>himyarita</i> ♂	mm. 2.28	mm. 0.64	mm. 0.14	mm. 0.38	mm. 0.38	mm. 0.66	mm. 1.81	mm. 0.51
" ♀	2.43	0.66	0.18	0.41	0.40	0.69	1.90	0.57
<i>biplagiata</i> ♂	2.43	0.66	0.15	0.37	0.39	0.68	1.95	0.53
" ♀	2.62	0.67	0.17	0.38	0.39	0.71	—	—

As the internal genitalia of *H. biplagiata* have not yet been figured or described, I reproduce for comparison's sake a series of figures (figs. 10, 18–22) made from the ♂ cotype at my disposal. They are drawn to the same scale as the corresponding figures of *H. himyarita* and they clearly demonstrate the above-mentioned differences between the two species discussed. I wish to emphasise the most extraordinary shape of the aedeagus and its articulating armature, found in *H. biplagiata*.

3. *Cicadulina bipunctella zeae* (China 1926).

1926, *Cicadulina zeae* China, *Bull. ent. Res.* **17** (1): 43, fig. 5.

1928, *Cicadulina zeae* China, *Bull. ent. Res.* **19** (1): 61.

1936, *Cicadulina zeae* China, *Bull. ent. Res.* **27** (2): 252, fig. 1b and b'.

1935, *Cicadulina bipunctella* Zakhvatkin, *op. cit.*: 111.

Hodeida, 26–29.ix.; 1 ♂.

In my paper of 1935, I identified *C. zeae*, known then in the female only, from Nairobi, Kenya Colony, with *Cicadula bipunctella* Matsumura 1908 (*Journ. Coll. Sci. Univ. Tokyo* **23** (6): 12) from Port Said. Additional information on the male of *zeae*, given by Mr. China in 1936, together with an examination of a series (3 ♂, 1 ♀) of *bipunctella* from Palestine (Ben-Shemen near Ludd, northern Judea) shows, however, my conclusion to be not fully correct. In fact, the Tanganyika ♂ described and figured by China as probably typical *zeae* as well as my own Yemen specimen, that seems to be of the same race, are certainly distinct from Palestine *bipunctella*, which I suppose to represent the typical form of this species. So far as can be ascertained on the rather scanty material now available, *bipunctella* differs from *zeae* in the following particulars:

Size, slightly smaller.³ General colour decidedly paler and of a more dull appearance; the orange (egg) yellow coloration distinctly not so deep and mainly restricted to the clypeus, the median part of vertex and two moderately large areas on pronotum close to its posterior angles; the median part of pronotum of a similar tint, but paler; the rest of the head and pronotum as well as the whole scutum, rather pale chrome-yellow. The black spots of the vertex seem to be comparatively smaller than in *zeae*: in the males, their greatest (transverse) diameter contained 3.5 to about 5 times in the inter-orbital width and correspondingly 2 to 5 times in the interspace between the inner margin of the spots; in the single available female, the corresponding proportions are 4.75 and 3.1. Dorsum in the male but slightly infusate, the darker areas of the tergites being rather

³ Mr. China gives no data on the dimensions of his species in the original description but in his 1928 paper he gives the total length of ♀ as 3.2 mm.

indistinctly divided by a somewhat paler median longitudinal line; in the female, almost concolorous with the rest of the body (pale chrome-yellow), only washed with fuscous. Front tibiae not infusate.

Male genitalia (figs. 23-25) as in *zeae* (figs. 26-27), but the dorsal spine-like appendages of aedeagus arise widely apart from one another and are implanted quite asymmetrically, one of them always much nearer to the base than the other; they may be said to have a distinct tendency to move in a distad direction, but quite separately and not as a paired unit.

The measurement of the Palestine specimens of *bipunctella* are given in the following table :

No. of specimen, data, and sex	Total length	Length of vertex	Inter- orbit. width	Width across eyes	Length of pro- notum	Poste- rior width of pro- notum	Length of teg- mina	Width of teg- mina
1. 29-30.ix.25 ♂	mm. 2.76	mm. 0.19	mm. 0.33	mm. 0.67	mm. 0.33	mm. 0.62	mm. 2.28	mm. 0.57
2. 25-26.viii.25 „	2.76	0.19	0.35	0.68	0.38	0.65	2.30	0.58
3. 14-15.viii.25 „	2.73	0.21	0.33	0.66	0.33	0.62	2.25	0.56
4. 13-14.vii.25 ♀	3.12	0.23	0.41	0.76	0.38	0.60	2.62	0.63

The above statement shows clearly enough that *bipunctella* and *zeae* are not synonymous. At the same time the differences between the two forms should not be over-estimated, since despite their obviousness they are considerably slighter in comparison with those usually distinguishing any two species of *Cicadulina*.

In my opinion, they are of a purely racial value, and I regard *bipunctella* as a well-marked northern geographic race of *zeae*, and no more. The name *bipunctella* being the older, should therefore be used for the species, and *zeae* coupled with it in a subspecific sense.

As already mentioned, the male specimen from Hodeida appears to belong to that more southern race, *C. bipunctella zeae*. Its genitalia (figs. 26-27) exhibit all the particulars displayed by Tanganyika specimens; it has likewise an entirely black dorsum, and is as brightly coloured as they seem to be. Moreover, it is distinctly smaller than the Palestine males, its measurements being as follows:—Total length, about 2.50 mm.; width across eyes, 0.67 mm.; length of vertex 0.18 mm.; int.-orb. width 0.31 mm.; length of pronotum 0.31 mm.; posterior width of the same 0.62 mm. If such a racial identity of the Yemen specimen with the Tanganyika insects proves to be the case, that will confirm the correctness of Mr. China's view that the latter do represent the same form which populates Kenya Colony, where the typical locality of *zeae* is situated.

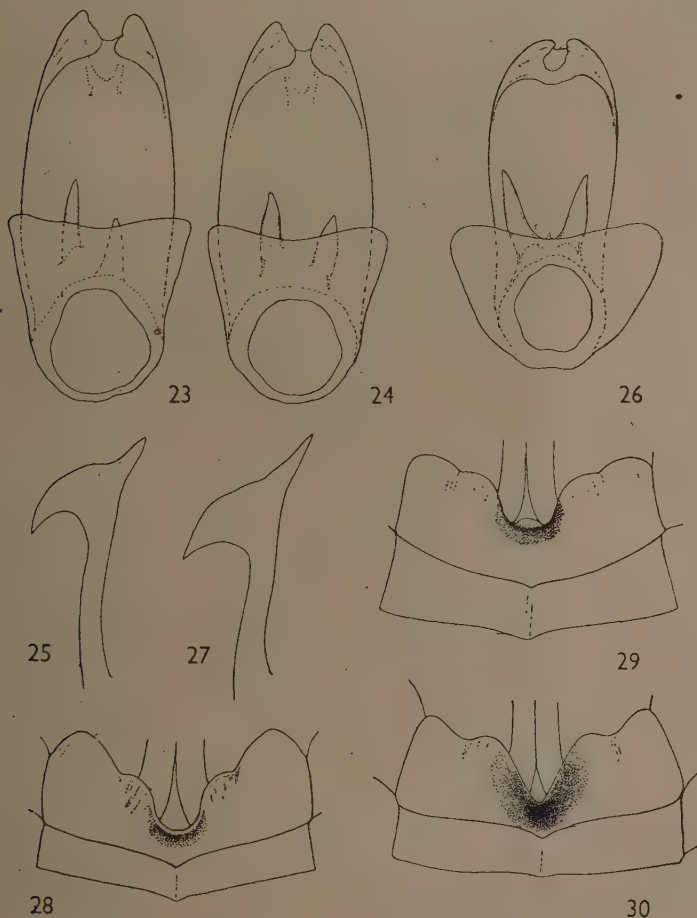
Finally, a curious fact is to be noted : viz., the principal differences, distinguishing *zeae* and *bipunctella* are of the same nature as those between the former species and *C. storeyi*. As should be remembered, they mainly consist in the presence of an unpigmented median stripe along the dorsum and the obvious tendency of the dorsal processes of the aedeagus to move distad. In *storeyi*, both these features reach their highest degree of development, the pale stripe being quite contrasting and the processes assuming a subterminal position; as

to *bipunctella*, it exhibits them in a fairly vestigial condition. At all events, *bipunctella* is modified on the same general lines of variation as *storeyi*, but in a far lesser degree.

4. *Cicadulina mbila* (Naudé 1926).

Hodeida, 26.ix.; 1 ♂.

This very distinctive species seems to be much more widely distributed over the Eremian region than is generally believed, as I have seen a specimen of it from Tadzhikistan in the collection of the Leningrad Museum.



FIGS. 23-30.—23-24, *Cicadulina bipunctella bipunctella* (Mats.) ♂, aedeagus; 25, process of pygophor. 26, *C. b. zeae* (China) ♂, aedeagus; 27, process of pygophor. 28, Subgenital plate of *Circulifer chinai* sp. n. ♀; 29, of *C. arabicus* sp. n. ♀; 30, of *C. jenjouriste* sp. n. ♀.

5. *Macrosteles sexnotata* (Fallén 1824) Ribaut 1925.

Hodeida, 26.xi.; 1 ♂, 2 ♀.

The genitalia of the male specimen from Hodeida shows no appreciable differences from those of typical European insects. Of course, the geographical variability of this widely distributed species awaits further investigations.

6. *Circulifer*⁴ *chinai* sp. n.

Sanaa, 24.ix.; 1 ♀.

♀. Pale greenish-yellow, with a definite whitish wash, completely opaque; vertex, anterior part of pronotum and scutum of a somewhat deeper lemon-yellow tint, while the disc of the pronotum and the tegmina seem to be more greenish, as they overlies black pigmented parts of the mesonotum and dorsum. Moreover, a characteristic pattern is obtained by the white coloration of the folded anal lobes of the hind-wings, which are clearly seen through the semitransparent tegmina and produce the impression of forming an angular whitish spot across the basal halves of the latter. Eyes fuscous, ocelli clear yellow, antennal pits narrowly infusate. Legs pale yellow, without dark plate at the base of the tibial bristles. Dorsum black with the lateral margins of tergites II (I)–VII rather broadly yellowish; VIII and IX tergites yellow with a narrow black margin which, on the latter, is divided into two separate crescent-shaped spots. Base of venter and some markings on the underside of thorax, fuscous; last ventrite with a light ferruginous spot around its median incision.

Stature rather robust; the width across eyes contained only 3.22 times in the total length. Vertex less than two-thirds as long as wide between eyes (3 : 5), but slightly longer medially than next the eyes (5 : 4). Pronotum twice broader than long in the middle. Tegmina moderately long, 3.30 times as long as wide, extending fairly well beyond tip of abdomen.

Subgenital plate (fig. 28) with a very deep and rather narrow median incision extending more than half-way to the base of the ventrite and almost semicircular in outline; lateral angles well produced in the form of bluntly pointed free lateral lobes; hind margin rather deeply sinuate on each side between middle and lateral angles, leaving two rounded, nearly semicircular submedian lobes; the ferruginous spot at the median incision fairly broad, crescent shaped, vaguely limited and encircling only the deepest part of the incision.

Measurements:—Total length, 2.90 mm.; width across eyes 0.90 mm.; length of vertex 0.23 mm.; inter-orbital width 0.38 mm.; length of pronotum 0.40 mm.; width of the same 0.83 mm.; length of tegmina 2.38 mm.; width of tegmina 0.71 mm.

The species discussed seems widely distributed throughout the Eremian region, extending eastwards as far as the northern Caspian Province. In the sandy deserts of the Astrakhan district, for instance, it is represented by a somewhat larger and more brightly coloured race, *caspius* subsp. n., which occurs on different halophilous species of Chenopodiaceae, such as *Halocnemum strobilaceum* (Pall.) M.B., *Kalidium foliatum* (Pall.) Moq. and some others, and still more abundantly on a weed, *Chenopodium glaucum* L. It seems thus probable that the typical form of *C. chinai* lives under similar ecological conditions.

I take particular pleasure in naming this species after Mr. W. E. China, the well-known British hemipterologist.

⁴ This genus was established in my previous paper (1935, *loc. cit.*) on the Homoptera of Yemen for the very numerous species centring about *Thamnotettix haematoceps* Mulsant & Rey, 1855, as type. Its detailed description will be given elsewhere.

7. *Circulifer arabicus* sp. n.

Hodeida, 26.ix.; 1 ♀.

♀. Entirely pale sulphur-yellow, rather opaque, without any definite dark markings except a deep chestnut-brown spot around the notch of the subgenital plate; dorsum but very slightly infuscate. Eyes fuscous, ocelli orange-red. Tegmina dull yellowish-white with lemon-yellow venation, the claval veins, *Cu* and *M*, being of a deeper tint than the radial system and, consequently, more conspicuous. Legs of the ground colour; tibiae without dark dots at bases of their bristles.

Stature, slightly less robust than in the preceding species: width across eyes contained about 3.34 times in the total length. Vertex about two-thirds as long as wide between eyes, distinctly longer medially than next the eye (4:3). Pronotum somewhat more than twice broader than long in the middle (19:9). Tegmina rather broad, 3.23 times as long as wide, extending fairly well beyond apex of abdomen.

Subgenital plate (fig. 29) more than semicircularly notched about half-way to the base medially and faintly concavely sinuate on each side between middle and lateral angles, leaving thus two bluntly rounded submedian lobes; lateral angles broadly rounded, barely exceeding the latter; the median incision wider than usual, exposing the base of the ovipositor sheaths on their whole breadth, with a small rounded membranaceous lobe in the middle; the rather narrow brown spot surrounding them has very definite semicircular outlines and does not extend posteriorly to the inner ends of the submedian lobes.

Measurements:—Total length 3.12 mm.; width across eyes 0.93 mm.; length of vertex 0.29 mm.; inter-orbital width 0.43 mm.; length of pronotum 0.43 mm.; width of the same 0.90 mm.; length of tegmina 2.52 mm.; their width 0.77 mm.

This species is apparently allied to *C. dubiosus* (Matsumura 1908) from Sicily.

8. *Circulifer jenjouriste* sp. n.

Hodeida, 26.ix.; 1 ♀.

♀. Dirty-white, opaque, with a light yellowish tinge more conspicuous on the fore part of pronotum, scutum and the venation of tegmina. Head slightly suffused with ochreous. Eyes ochreous grey, ocelli orange, antennal pits and the clypeal sutures very narrowly blackened. Tegmina dull whitish, veins pallid, apices of R_{2+3} and R_{4+5} lying on very small triangular fuscous spots. Legs pallid, the bristles of the ventro-external row arising from small blackish spots. Dorsum broadly banded with fuscous on tergites II–VII, the stripes gradually diminishing in width caudad; the bases of the VIIIth and IXth tergites are narrowly but almost completely encircled with fuscous; the remainder yellowish-white. Venter yellowish-white with a semicircular fuscous spot at base that almost covers the median part of the two first ventrites; subgenital plate with a very large ferruginous spot surrounding its median incision.

Stature, relatively slender, almost as in *C. haupti* A.Z. 1935 (= *unicolor* Haupt 1927, not Melichar 1902); width across eyes contained about 3.50 times in the total length. Vertex short, somewhat less than twice as wide as long in middle (9:5), scarcely longer medially than next the eye (10:9). Pronotum exactly twice broader than long in middle. Tegmina comparatively long, 3.41 times as long as wide, extending well beyond the tip of abdomen.

Subgenital plate (fig. 30) with a very deep triangular median notch, reaching rather close to the base of the ventrite; with narrowly rounded and somewhat produced lateral angles and posterior margin concavely sinuate each side of middle, leaving thus two bluntly rounded submedian lobes; spot around the median incision very large and conspicuous, extending cephalad to the base of the ventrite and caudal nearly to the middle of the submedian lobes.

Measurements :—Total length 3.33 mm.; width across eyes 0.95 mm.; length of vertex 0.29 mm.; inter-orbital width 0.43 mm.; length of pronotum 0.45 mm.; width of pronotum 0.90 mm.; length of tegmina 2.75 mm.; width of tegmina 0.81 mm.

A species, rather similar in general appearance to *C. haupti* A.Z., from Palestine, but easily distinguishable from the latter by the structure of the female subgenital plate and some other particulars.

The species is dedicated to its collector, Mr. N. N. Jenjouriste.

Vol. 96. Part 10. Pp. 163-186.*

20th June, 1946

COMMONWEALTH INST.
ENTOMOLOGY

10 AUG 1948

SERIAL Ent. 344
SEPARATE

THE

TRANSACTIONS

OF THE

ROYAL

ENTOMOLOGICAL SOCIETY

OF

LONDON

World List abbreviation: Trans. R. ent. Soc. Lond.

CONTENTS

	PAGE
+ WILTSHIRE, E. P., F.R.E.S. Studies in the geography of Lepidoptera.—III. Some Middle East migrants, their phenology and ecology	163-182

LONDON:

PUBLISHED BY THE SOCIETY AND
SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 7s. 6d.

* With title-page, contents and index.

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Founded, 1833. Incorporated by Royal Charter, 1885.

PATRON—HIS MAJESTY THE KING.

OFFICERS and COUNCIL for the SESSION, 1946-1947.

PROF. G. D. HALE CARPENTER, M.B.E., D.M., *President*.

W. J. HALL, D.Sc.

C. B. WILLIAMS, M.A., D.Sc. } *Vice-Presidents*.

H. B. WILLIAMS, LL.D. }

A. WELTI, *Treasurer*.

N. D. RILEY, *Secretary*.

Other Members of Council.

C. H. ANDREWES, F.R.S.

J. W. EVANS, M.A., D.Sc.

G. FOX-WILSON, N.D.H.

R. M. GREENSLADE.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

CAPT. R. A. JACKSON, R.N.

MISS C. E. LONGFIELD.

SIR GUY A. K. MARSHALL, K.C.M.G.,

D.Sc., F.R.S.

G. E. J. NIXON, B.A.

J. F. PERKINS, B.Sc.

Registrar :

Finance and House Committee.

G. FOX-WILSON, N.D.H. (Chairman).

J. W. EVANS, M.A., D.Sc.

FRANCIS HEMMING, C.M.G., C.B.E.

H. E. HINTON, B.Sc., Ph.D.

W. RAIT-SMITH.

O. W. RICHARDS, M.A., D.Sc.

Publication and Library Committee.

W. J. HALL, D.Sc. (Chairman).

H. E. HINTON, B.Sc., Ph.D.

B. M. HOBBY, M.A., D.Phil.

J. F. PERKINS, B.Sc.

J. SMART, B.Sc., Ph.D.

W. H. THORPE, M.A., Sc.D.

Committee on Generic Nomenclature.

FRANCIS HEMMING, C.M.G., C.B.E. (Chairman).

W. A. F. BALFOUR-BROWNE, F.R.S.E.

K. G. BLAIR, D.Sc.

O. W. RICHARDS, M.A., D.Sc.

N. D. RILEY (Secretary).

Committee for the Protection of British Insects.

H. M. EDELSTEN, O.B.E. (Chairman).

R. B. BENSON, M.A.

E. A. COCKAYNE, M.A., M.D., F.R.C.P.

CAPT. R. A. JACKSON, R.N.

COL. F. A. LABOUCHERE.

A. M. MASSEE, D.Sc.

THE HON. MIRIAM ROTHSCHILD.

W. H. THORPE, M.A., Sc.D.

N. D. RILEY (Secretary).

The Executive Officers of the Society are *ex-officio* members of all Committees.

DELEGATES OF THE SOCIETY TO :

1. British National Committee for Biology (Royal Society).

Mr. Francis Hemming, C.M.G., C.B.E., appointed 1946.

Dr. V. B. Wigglesworth, M.A., B.Ch., M.D., F.R.S., appointed 1943.

2. Local Committee of Management of Wicken Fen.

Mr. H. M. Edelsten, O.B.E. [nominated by Committee for the Protection of British Insects].

3. National Trust for Places of Historic Interest or Natural Beauty.

Mr. H. M. Edelsten, O.B.E., appointed 1944.

4. New Forest Association.

Mr. W. Fassnidge, appointed 1934.

5. New Forest Joint Committee.

Mr. W. Fassnidge, appointed 1939.

Dr. F. J. Killington, D.Sc., A.L.S., appointed 1939.

6. Royal Meteorological Society. Phenological Committee.

Dr. C. B. Williams, M.A., D.Sc., appointed 1937.

7. Biology War Committee.

Prof. P. A. Buxton, M.A., F.R.S., appointed 1941.

8. Council for the Promotion of Field Studies.

Dr. W. H. Thorpe, M.A., Sc.D., appointed 1944.

9. Joint Bioclimatic Committee.

Dr. B. P. Uvarov, C.M.G., D.Sc., appointed 1945.

Dr. C. B. Williams, M.A., D.Sc., appointed 1945.

STUDIES IN THE GEOGRAPHY OF LEPIDOPTERA.—III.¹ SOME MIDDLE EAST MIGRANTS, THEIR PHENOLOGY AND ECOLOGY

By E. P. WILTSHIRE, F.R.E.S.

Manuscript received 10th April, 1945.

(Read 7th November, 1945.)

SOME notes by me appeared in a short paper (1940) summarising briefly the phenology and presumed movements of the chief Lepidoptera-migrants of the Middle East. Further observations of these species were continued after that date in the same area until 1944, when I left the Middle East.

The present work is an attempt to correlate all these observations, with the addition of certain other records from the same localities, with the ecology of the localities. The eight migrant species selected for this purpose are those for which the greatest number of records were available. A few new records of some of the remaining migrants are also included, as additional contributions to the study of their migrations.

My records from the Lebanon and Palestine are omitted from the present study, chiefly because precise records of occurrences at Lebanese Middle Heights were in my opinion necessary but in fact not accessible. Consequently the area covered by this paper is the whole Mesopotamian-Iranian hinterland from Palmyra in the Syrian desert eastward across Iraq to Tehran and Yezd (Central Iran) and south-eastward to Kuwait (E. Arabia) and Bushire and Firuzabad (S.W. Iran). The Lebanon and Anti-Lebanon ranges cut off this vast area from the direct influence of the Mediterranean Sea. In the extreme South-East a maritime influence slightly mitigates its continental climate but even here it is far less favourable than the Mediterranean climate.

My collated records cover a period of ten years (1935-44) spent in this area; the records of the two other observers included are, in one case, for the year 1918, and, in the other, for 1936.

For the sake of easy comparison, these records have been compressed into a table or spectrum for each species, showing its appearances, as adult and larva, in each climatic type of locality in each month of the year (Table 1). The non-mention of the larva, however, usually represents a failure to observe the larva, and does not necessarily mean that the species was not, in that month, in the larval stage.

While different localities in the area have their own climatic peculiarities, the grouping of all of them into five broad climatic types or biotopes was necessary and possible. The actual details and minor variations under each type are given in the "Description of Biotopes" (p. 165).

In Great Britain the difference in immigration is very marked between one year and another; this is largely because the migrants immigrate from remote sources, and only if weather, or other factors, are favourable do they arrive at all. But the migrants of the Middle East, with a few exceptions

¹ Previous articles in this series were: I. Types of evidence for historical theories (1944, *Ent. Rec.* 56 : 73-74). II. Swallow-tails in desertic S.W. Asia (1945, *Proc. R. ent. Soc. Lond.* (A) 20 : 16-25).

such as *Catopsilia florella*, have their headquarters within the Middle East; similar mass movements of Lepidoptera therefore seem to occur every year in the Middle East, and weather, or other factors, while doubtless affecting the number of emigrants, do not stop migrations within the area. Possibly because I never resided more than two consecutive years in any one locality and thus could not compare numbers of migrants in the same locality from year to year, I observed no periodicity in migrations, and no "good" or "bad" years. The tables, compressing the records of several years into a single span of twelve months, may be taken as showing the average or norm in the appearances and absences of the species tabulated.

Towards the end of my residence in the Middle East I began to search for these migrants and their early stages, with a view to finding more tangible evidence of their movements, but most of my records, whether of single adults, migrating adults, or larvae, were made incidentally to general collecting and field work, and in leisure hours; the two other authors' records were similarly incidental. Lacunae therefore may be due to omission to record common species seen (and these species are all common ones) rather than being always due to a true phenological absence. On the whole such chance lacunae will have been filled up by the accumulation of records over the many years covered, so that the tables on the whole give a fairly accurate picture of the phenology of the various species. An attempt has been made, however, to distinguish the chance lacunae, not eliminated in this way, from true phenological absences by filling up the blank, in the case of the former with the bracketed symbol of the adult stage (a) or the larval stage (l). These parentheses, of course, represent my opinion, an opinion based on field observations and breeding results. The true phenological absences, represented by blanks, in most cases imply a definite absence noticed despite search (though this is not so where the search would have been dangerous, impossible and, incidentally, useless, e.g. mountain-tops in winter). In a few places a blank has been left when I am doubtful whether the lacuna is accidental or significant (e.g. for *A. ypsilon*); these cases of doubt are due to not having elucidated the early stages in the Middle East. The presences recorded in the tables represent a total of 278 different single records (not necessarily of single individuals) for the total of 10 species tabulated. The number of records from each biotope is shown in the "Description of Biotopes" below.

The tables therefore, while depicting phenologies do not, except where expressly indicated, record an observed migration. They distinguish between a record of one or a few individuals, on the one hand, and larger numbers, on the other; but the value of the tables as evidence of migration depends on the life-cycle of the individual species, for a true phenological absence may be due to (a) emigration, or (b) dormancy (diapause). This point will be discussed below under the section "The distinction between migrant and non-migrant."

Non-migratory multivoltine (i.e. continuously-brooded) species often undergo a short diapause in the Middle East, while the diapause of bivoltine (two-brooded) and univoltine (single-brooded) species is usually longer. Two non-migratory multivoltine species are tabulated as "controls" from records of their phenology in the same localities as the migrants; but bivoltine and univoltine species have not been tabulated, as their life-cycle is too different to shed any light on the possible effects of the environment on the migrants.

DESCRIPTION OF BIOTOPES.

General climate of the area.

The common feature in the climate of the whole area is its dry summer and its sub-tropical continental character. The rainfall is probably nowhere above an annual average of twenty inches and indeed over most of the area is below ten inches. This rain falls only during the winter half-year and its quantity varies widely from year to year. Occasional summer squalls or hail-storms are of no climatic significance. Despite the influence of the Lebanon and Anti-Lebanon ranges, the "rain-shadow" of which desiccates the Syrian desert, all the rainfall of this area is derived from the westerly cyclones from the Mediterranean basin. These storms periodically interrupt the prevailing dry north wind.

Within this broad climatic type, two widespread sub-climates can be distinguished: (a) the desert climate of the Mesopotamian lowlands, and (b) the plateau climate of the Iranian table-land. A third sub-type or variation is (c) the plateau-rim, or "Zagros" climate, which occurs in a zone like a narrow elongated wedge between (a) and (b); it has a higher rainfall than its two neighbouring climates and is the only part of the area with a rainfall considerably over an average of ten inches annually. (N.B.—The Caspian forest-zone, on the north side of the Elburz Mts., is not included in the area here discussed owing to an almost total lack of records; its climate is quite different from that of the rest of Iran, and from that of Iraq and Syria, since the rainfall is distributed all the year round, and heavier. This humid forest-zone undoubtedly plays an important rôle in Middle East insect migrations, which unfortunately cannot here be discussed; presumably its humidity will make it a refuge for summer emigrants from the parched territory, but its cold, if short, winter may make it unsuitable as a winter refuge.)

Inside each of the sub-types (a), (b), and (c), an important eco-climatic subdivision is necessary, between the "oasis" biotope on the one hand, and the desert, steppe, or scrub-woodland biotopes on the other. The "oases" are habitats provided with a water-supply in addition to that of aerial precipitation. Owing to the low annual rainfall and the arid summers, the contrast in scenery and climate between an oasis and the adjacent ground is most striking; it might be less striking in the scrub wood zone of the Zagros if the artificial oases were not usually there the centres of circles of deforestation, reducing the primarily-wooded hillsides and plains to secondary steppes.

Upper Heights (UH).

Like the Middle Heights and Lower elevations, the Upper Heights could also be subdivided into moist and dry biotopes, but this division, though significant for many stenoeccous species, is not significant for the migrants at Upper Heights, except perhaps for *N. noctuella*.

The Upper Heights occur as islands in the plateau climatic area, and the Zagros (scrub) area.

Owing to the long dry summer they are subject to strong insolation and evaporation as well as the strong winds typical of all mountain-peaks wherever situated. The range in temperature is extreme, between summer and winter, day and night, and light and shade. Ultra-violet radiation is intense.

These heights are regularly and continuously snow-clad in winter, except

TABLE 1.

Months.

Species	Biotope	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
<i>Migrants</i> <i>Vanessa</i> <i>cardui</i>	UH MH MHO D DO	 a a lha	 a LA a	 a LA A	 A la HA A	 a la a	 a a a	LHA a a ?	A A A ?	 a (a) a a	 a A a a	 A A la a	 a a
<i>Colias</i> <i>croceus</i>	UH MH MHO D DO	 a	 a (a) a a	 a a a a	 a a A a la	 a a (a) a la	 a a (a) a la	 a a a (a)	 a a a a	 a (a) a a	 a a a a	 a a a (a)	 a a (a)
<i>Glycestha</i> <i>aurota</i>	UH MH MHO D DO	 (a) a	 (a) (a)	 a a	 a a	 	 	 	 a a (a)	(la) (la) (la)	(la) (la) a	la a LA a	 a (a) a
<i>Celerio</i> <i>lineata</i> <i>livornica</i>	UH MH MHO D DO	 a	 l A	 A LA la	 (a) a LA la	 (a) (a) a a	 a (a) a a	 a 	 	 (a) (a) a	 	 	
<i>Agrotis</i> <i>ypsilon</i>	UH MH MHO D DO	 a	 a	 a (a)	 a a	 a a	 a a	 	 	 a a	 a a	 a a	 a a
<i>Laphygma</i> <i>exigua</i>	UH MH MHO D DO	 a (a)	 a a (a)	 a (a) a	 a a (a)	(a) a LHA A	 a a a a	 a a a	 A	 a a la	(a) a a ha	(a) a (a) ha	 a (a) (a)
<i>Phytometra</i> <i>gamma</i>	UH MH MHO D DO	 a	 a	 a a	 a LHA	 a (a)	 a a	 (a) a	 (a)	 a a	 a a	 a a	
<i>Nomophila</i> <i>noctuella</i>	UH MH MHO D DO	 a a	 a a (a)	 a a A	 a a A	(a) a a a	(a) a a a	 a a a	 (a)	 a a	(a) a (a)	 a (a) a	 a
<i>Non-Migrants</i> <i>Melitaea</i> <i>trivia</i>	UH MH MHO D DO	 a	 a a	 a la a	 la a	lha lha a	lha (a) a	 a	(la)	 a a	 a a	 	

TABLE 1—continued.

Species	Biotope	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
<i>Polyommatus phloea</i>	UH					a	a	(a)	(a)				
	MH				a	a	(a)	a	a	a			
	MHO		a	(a)	(a)	a	(a)	a	(a)	a			
	D												
	DO		a	a	a	a	a	a	a	a	a	a	

Key to abbreviations and symbols used above.

L = larvae numerous } N.B.—The absence of L or l or (l) does not mean that the larvae
l = larvae recorded } are thought to be necessarily absent.

H = numerous adults emerged from pupae.

h = adults emerged from pupae.

A = adults numerous } A = numerous adults seen migrating northwards.

a = adults recorded } A ⇒ ditto, northwards and westwards, on different occasions.

(a), (la) = no record for this month, but lacuna is probably not significant, i.e. species probably present.

? = record not confirmed by an entomologist.

UH = Upper Heights (43 records). MH = Middle Heights (50 records).

MHO = Middle Height Oases (37 records). D = Desert (64 records). DO = Desert Oases (84 records).

I, II, etc. = January, February, etc.

where the slope-angle is too steep; in the summer, except where the snow still lingers, the biotope reveals itself as a herbatum, with thistles and spiny cushion-bushes prominent in a very mixed plant-association, in which grasses vary from sparse to almost absent except on moist pockets near springs where patches of turf are enabled by the water to exist.

In the Zagros scrub zone this biotope overlaps into the upper part of the wooded zone; the tree-line in the north is lower than in the south Zagros. The Upper Height localities situated in the Zagros zone or scrub sub-climate are marked below with an asterisk. As far as migrations are concerned, it makes little difference whether the Upper Height biotope is in the Zagros zone or the more arid plateau, except that the Zagros Upper Heights are nearer to the lowland desert than are the others. Since at these heights summer is the season of growth, and no rain falls in the summer in either sub-climate, the Upper Height biotopes in these two climatic areas, which differ from one another mainly in their rainfall, differ less than the Middle Height biotopes.

At these heights the main climatic obstacle to insect development is presented by the winter's cold; the summer drought is only operative in the extreme south, where summer is much longer; elsewhere, by the time the plants on which the migrants' offspring have fed are becoming desiccated for lack of moisture, the earlier autumn sets in and induces a downward emigration in the mass of the adult population; those remaining are presumably killed by the cold.

List of Upper Height localities tabulated.

**Ser Amadia*, 6,000 ft. Lat. c. 37° N., Long. c. 43° E. Kurdistan, Iraq.
Several visits in summer 1935.

**Rayat*, 5,000–9,000 ft. Lat. c. 36° 30' N., Long. c. 45° E. Kurdistan, Iraq.
Several visits in summer 1935.

- S. side of Elburz Range*, 7,000–14,000 ft. Lat. c. 36° N., Long. 53°–52° E. N. Iran. Various mountains were visited by me in summers 1939 and 1943; also some records by Schwingenschuss of his 1936 visit.
- Alvand*, 7,000–11,000 ft. Lat. c. 35° N., Long. c. 49° E. Iran. Several ascents during summer 1938.
- **Karind*, 6,000 ft. Lat. c. 34–30° N., Long. c. 46–30° E. Iran. Material collected by Peile in summer 1918, reported in *J. Bombay nat. Hist. Soc.* Neighbouring ranges of the same altitude were visited by me during my stay at Kermanshah, 1939–40.
- Kuh Chavireh Shah* and other Luristan heights, c. 7,000 ft. Lat. c. 33° 30' N., Long. c. 49° E. Briefly visited during summer 1938. Iran.
- Kuh i Suffeh*, 8,000 ft., and other mountains near Isfahan. Lat. c. 32° 30' N., Long. c. 51° 30' E. Visited during winter 1941–42. Iran.
- Barfkhaneh*, 9,000–13,000 ft. Lat. c. 31° 30' N., Long. c. 54° E. Iran. Early June 1940.
- Quli Kush Pass*, c. 8,000 ft. Lat. c. 31° N., Long. c. 53° E. Iran. Visited briefly several times, 1940–41.
- **Barm i Firuz*, 10,000–12,250 ft. Lat. c. 30° 30' N., Long. c. 52° E. Fars, Iran. Twice visited in summer 1941.
- **Shiraz district mountains*; eight different peaks around Shiraz, 6,000–10,000 ft. Lat. 29° N., Long. c. 53° E., visited in summers 1940–41. Fars, Iran.

(* The asterisks indicate localities in the Zagros zone.)

Middle Heights (MH).

The Middle Height biotope shows considerable diversity over the whole area, even after the exclusion of the oases as a distinct biotope. The Zagros Middle Heights are a distinct biotope from the inner plateau Middle Heights, but the difference is less significant for migrants than for stenoeccous species, and here these two biotopes are combined.

The greater part of the area of Middle Heights consists of the open plateau of Iran, composed of rocky lower mountain-slopes, long gradual slopes of gravel with a characteristic steppe vegetation (herbetum) and small patches of alluvium in many of the valleys. The latter may be cultivated ground or salty waste land. In the Zagros, where the rainfall is over ten inches annually, both mountains and plains were originally covered with scrub woods, much of which still survive, but in the interior where it is usually less than ten, they have always been treeless except in the oases, which are dealt with separately below. In the list below, an asterisk marks the Zagros Middle Heights; they have better grass than the plateau Middle Heights.

The variations of temperature, though less than at Upper Heights, are still great. At Isfahan a normal variation of 50° F. in 24 hours occurs, and of course the difference between the summer maximum and the winter minimum is far greater, indeed probably double. At Shiraz, a milder climate, the daily range is still as great as 30° F. Snow melts soon after falling on the steppe slopes and plains, but on the mountains its disappearance depends more on the exposure of the particular slope on which it lies. At these heights much of the winter precipitation comes as rain. The summer is hot and very dry, though usually the heat does not exceed 100° F. in the shade; the summer thus constitutes an obstacle, equal to, if not greater than, the winter, to insect activity, which is therefore greatest in spring and autumn. Nevertheless, midsummer sees many non-migrant species still on the wing, especially in the

scrub-woods, and there is reason to believe that day-flying migrants, to judge from their congregation in Middle Height oases (see below), are able at these heights to survive summers and winters in some places and to some extent. Fuller records should make this clear.

List of Middle Height localities tabulated.

**Amadia*, *Diana* (nr. Rowanduz), *Suleimani*, and many other Kurdish localities in N. Iraq, between Lat. 37° and 35° N., and between Long. 43° and 46° E. Visited in summer 1935 and spring and autumn 1936; one or two records were also mentioned from this area and elevation in the *J. Bombay nat. Hist. Soc.*, and specimens were also received from Amadia taken during the summer 1937.

Tehran district; hilly steppe and other Middle Heights between Lat. 36° and 35° N., and Long. 51° and 52° E. were visited in spring, summer and autumn 1939 and again in summer 1943. Towards Qum this arid steppe and steppe-mountain biotope becomes desert-like at 3,500 ft. Iran.

**Pai-Taq* and *Karind*, 2,000–5,000 ft. Lat. c. 35° N., Long. c. 49° E. Material collected by Peile in summer 1918 was listed in *J. Bombay nat. Hist. Soc.* Localities between Kermanshah and Karind were also visited by me during autumn–winter 1939–40. Iran.

Isfahan, c. 6,000 ft. Lat. c. 32° 30' N., Long. c. 51° 30' E. Visited in summer, autumn and winter, 1940–42. Iran.

Yezd, 3,000–6,000 ft. Lat. c. 31° 30' N., Long. c. 54° E. Arid steppe and steppe mountains, as around Qum (see above, under Tehran). Visited in June 1940. Iran.

**Shapur*, near Kazerun, 3,000–4,000 ft. Lat. c. 29° 45' N., Long. c. 51° 30' E. Visited in autumn, winter and spring 1940–41. At 3,000 ft. the biotope is intermediate between S. Zagros scrub-wood and Saharan–Sindian desert, and palms are cultivated in the plain. Fars, Iran.

**Shiraz*, 5,000 ft. Lat. c. 29° 30' N., Long. c. 53° E. The author resided here 1940–41 and visited various deforested (= secondary steppe) or scrub-wooded localities at all seasons. Fars, Iran.

**Sarvistan* and *Firuzabad* districts, 4,000–5,000 ft. Lat. c. 29° N., Long. c. 53° E. The former was visited once in spring 1940, and the latter twice in spring and summer 1941. Fars, Iran.

(* The asterisks indicate localities in the Zagros zone.)

Middle Height Oases (MHO).

These differ eco-climatically from the surrounding unirrigated Middle Height biotope. They have hydrophytic vegetation, a higher humidity and frequently protection from the winds; this shelter is provided in the artificial oases by high walls as well as trees and shrubs, and in the natural oases by high banks or cliffs, often of gorge-like proportions. Insolation and evaporation are thus reduced in many Middle Height oases, with a corresponding reduction in the summer temperatures.

In the artificial oases, though human activity often interferes with the biotope, particularly in extirpating certain insect-foodplants, garden-flowers seem to play a rôle in enabling migrant *Lepidoptera* to survive both the winter and summer, attracting species from the surrounding country; at least these migrants are less frequently seen outside the gardens in midsummer and winter. A sunny day in winter may produce quite a profusion of butterflies, though a search for moths at night at that time is usually less successful.

Presumably this is because of the great diurnal range in temperature, whereby the season of flight of nocturnal insects begins later in the year and ends earlier than for day-fliers. I have noticed that sallow catkins attract many bees and some butterflies on the Persian plateau, but never any moths at night as in England; they bloom very early in the year. On the other hand, ivy-bloom is also not as attractive to moths as in Britain, though it comes out when moths are still on the wing.

The effective winter at these heights is short, viz. from mid-December to late February, and around Shiraz can be very mild.

If, as seems to be the case, these oases provide for migrants the possibility of activity all the year round, their comparatively small size makes them incapable of producing the vast numbers which seem to occur in many migrations; these masses are more probably the offspring of colonists of the vast unirrigated tracts which provide enormous quantities of foodplant for a short season. This, however, is a generalisation; the availability of foodplant is discussed below under "Peculiarities of each species." The migrations of each species are governed by its specific requirements and capacities.

There is no need to list the Middle Height Oases localities, since these oases occur in nearly all the Middle Height districts already listed above.

Desert (D).

Most of what is here called "desert" would be called "pre-desert" or "steppe-desert" by biogeographers. The Jerusalem school of phytogeographers have divided it into two regions by a line crossing the Euphrates at Hit. If one takes a species of plant or tree (*e.g.* the date-palm) to typify the desert climatic region, it will be easy to draw such a boundary, between the Northern "steppe" part (Iranian-Turanian region), where the palm cannot be cultivated, and the Southern "desert" part (Saharan-Sindian) where it can. But as an environment for migrant Lepidoptera it will suffice to remark that in the northern desert there are regular snowfalls, which quickly vanish, while in the south the winters are milder, and that these two desert climates grade into one another with no sharp frontier. The rainfall is especially low in the south-east, and in some years is almost negligible, though probably nowhere, in the area here considered, and in the localities worked, does it entirely fail in any year. At Kuwait the annual average is about 3 inches, whereas at Bushire, on the opposite shore of the Persian Gulf, it is over 10, doubtless because of the proximity of the Zagros mountains.

The summer, with its long heat and drought, constitutes the prime obstacle to insect activity throughout the desert; in the north, the winter is cold enough also to impede it for a short season. Insolation and evaporation are very strong in summer, though the former is less than on the plateau and high mountains because of the quantities of suspended dust in the air, scoured from the earth by the frequent strong winds.

Humidity is generally low, but in the south rises each time a cyclonic storm crosses the area, with the resulting southerly wind from the Persian Gulf. In winter humidities are comparatively high. Summer temperatures reach peaks of 125° F. in the shade throughout the area, both in desert and desert oases, and 150° F. or more in the sun in the desert.

The differences between alluvial and other types of desert terrain are less significant for migrants than for non-migrant Lepidoptera.

Annual vegetation appears during the winter months but has disappeared again by midsummer, leaving only the xerophytic perennials typical of the

desert; these rarely afford pabulum to migrant species. Emigration from the desert begins in April and is completed, even in the north, by June. Dependence on the short-lived annuals of this vast biotope is probably the explanation of the great migrations of butterflies and moths which in some years reach northerly latitudes but which reach the less remote mountain-tops of the Middle East annually. Certain species appear to migrate from the desert to the desert oases.

An annotated list of twenty desert localities was given in my paper on the Mesopotamian desert *Lepidoptera* (1941), there is therefore no need to repeat the detailed list here. They lie between Lat. 37° and 29° N. and Long. 38° and 51° E. The following desert localities have been worked subsequently :—

Basra and *Zubair*. Less than 50 ft. Lat. c. 31° N., Long. 48° E. I resided at the former and worked desert around the latter in 1942–1944. S. Iraq. *Kuwait* (E. Arabia), c. 50 ft. Lat. c. 29° N., Long. 48° E. Visited in May 1943 and March 1944. Valuable material was also received from Mrs. V. Dickson, collected in Kuwait and the surrounding desert during 1943–1944. The most southerly locality of this material was about Lat. 27° N., but these were only a few odd specimens; nevertheless these few included two migrant species.

Material received from farther south in Arabia, kindly sent to me by Mr. D. Vesey-Fitzgerald, is not included in this study except for one mention of *cardui* below (a record not tabulated above); it is hoped to catalogue this material in a future work.

Desert Oases.

These differ from the surrounding desert in the same eco-climatic way as the Middle Height Oases from the surrounding Middle Heights. Insolation, evaporation and summer temperatures are similarly reduced, though maximum shade temperatures are not noticeably less; shade, however, is almost non-existent in the desert, so the effective difference in temperature is that between the desert sun-temperature and the oasis shade-temperature, except in the case of subterranean desert animals. Winter-flowers play the same rôle in the desert oases as described above under Middle Height Oases, but to a greater extent, because of the milder winters and consequently greater abundance of flowers.

The great obstacle to insect activity is the long dry summer heat, but owing to the more favourable eco-climate, some, at least, of the migrants are able to live and develop throughout the summer. The winter is only an obstacle in the more northerly desert oases, which are transitional to Middle Height Oases as biotopes. Winter is short even here and mitigated by warm sunshine, so probably fails to kill off all the population.

The only desert oasis locality not listed in my 1941 paper is Basra, of which geographical details are given above under "Desert." Basra differs from the Central Mesopotamian oases in that the palm-groves are irrigated principally by tidal lift and not by pump. The absence of many oasis species which thrive at Bagdad shows that its extreme heat makes Basra a less favourable biotope in general than the Central Mesopotamian oases, though the Sudano-Deccanian element is stronger at Basra than at Bagdad.

PECULIARITIES OF THE DIFFERENT SPECIES.

A. *The distinction between migrant and non-migrant.*

It has already been remarked that a true phenological absence may be due to (a) emigration or (b) dormancy (diapause). If therefore one can be sure that a species is a migrant and incapable of diapause, the absences revealed by records must, if truly phenological, be proof of emigration. Similarly, in the control species, if one can be sure that the species performs a diapause but never migrates, the true phenological absences must represent a diapause. How sure can one be of these provisos?

My own breeding experience and that of many other Lepidopterists have shown that, as a general rule, migrants do not perform a diapause. A remarkable exception to this rule was recently published by Mr. G. P. Sutton, the species being *C. livornica*. Can this record, of a long diapause in the pupa of a normally multivoltine migrant, be reconciled with the general rule?

If Sutton's record is studied carefully, it will be seen that only one *livornica* pupa out of a whole brood performed the diapause; all the other pupae were subject to similar conditions but produced adults in the normal short period or died. The record therefore permits one to assume that the mass of the population of a multivoltine migrant continues its normal multivoltine phenology and continues to emigrate and immigrate again according to ecological conditions as revealed in the phenological table, while a very small minority may survive in a diapause without emigration; it certainly does not justify explaining the mass appearance of a multivoltine species after an absence as due to a mass emergence from a diapause; such an explanation is indeed, from the present evidence, inadmissible. Mass emergences after a diapause are indeed characteristic rather of univoltine species with a long diapause.

On the possibility therefore of migrants performing a diapause it is still permissible to conclude that the majority of every generation of a multivoltine migrant behaves in accordance with the breeding results of naturalists and that at the most a few individuals only do not conform. Some European migrants, e.g. *Pieris brassicae*, are known to be able to hibernate in one sense and probably cannot, to judge from Bodenheimer's records of this species in Palestine, aestivate; but the tropical and sub-tropical species considered here are, on the whole, unable to hibernate or aestivate in the true sense though probably able to survive the short cool sub-tropical winter.

The possibility that a species capable of diapause may migrate also requires consideration. This raises the all-important question of the distinction between migrants and non-migrants, and the following criteria are suggested as helpful: a species can be considered a migrant if it fulfils most or all of the following provisions:—(1) it has been observed performing a mass movement; (2) it has been taken, or seen on the wing, at sea; (3) it shows no geographical variation over a wide and diverse area; (4) both ² sexes occur occasionally, or sporadically, far from where it is known to breed and reside.

Non-migrants are those which fulfil none or at the most only one-third of the above provisions. Often the observed habits of a stenoeccous species are sufficient indication that it is not a migrant.

These criteria will enable one to establish two broad classes of migrants

² The importance of the above proviso "both sexes" will appear below when *M. trivia* is discussed.

and non-migrants. Admittedly, however, some of the latter possess a considerable degree of mobility. Other species may be carried considerable distances by the wind; it is not clear yet whether these can be distinguished from the voluntary migrants which, as often as not, are observed migrating against the wind. The existence of such doubtful cases and intermediates does not invalidate the broad distinction between migrants and non-migrants.

B. *Geographical Status.*

It is important to understand a migrant's geographical status, and therefore in the following notes on the individual species each species is classified zoogeographically.

Two of the eight migrants are shown to have their headquarters outside the area here considered, *P. gamma* to the north, and *G. aurora* to the south. The area is, however, only part of the headquarters for the remaining six. It is not possible to draw a sharp frontier-line between the headquarters-region of a migrant and the fringes of its maximum distribution, but the difference in its behaviour at points well within the headquarters and well outside is well marked. Outside, immigrations are usually more erratic, failing entirely in some years; inside, the migrant often appears to thrive and multiply equally in its summer and winter quarters, whereas outside it appears in one season only and multiplies less. In cases where a migrant winters without breeding in a region remote from where it breeds and multiplies, the latter region must be considered its headquarters, even if it is quite absent there in winter. Such cases, however, are rare in insects. Thus different criteria must be used in determining a migrant's and a non-migrant's geographical status, and the maximum range of the migrant must not be considered.

C. *Details and notes on the individual species.*

Migrants.

Vanessa cardui L.

New and Old World; sub-tropical and tropical.

General biology:—multivoltine, without diapause. The larva obtains some shelter by means of the leaf-tent it constructs, but the pupa is not subterranean.

Principal foodplants in the Middle East:—

(a) Upper Heights: thistles and occasionally *Urtica dioica* (stinging nettle). The latter only grows near running water.

(b) Middle Heights: thistles, which become desiccated in midsummer and autumn.

(c) Middle Height and desert Oases: *Althea* (cultivated hollyhocks) and *Cynara* (artichoke). The perennial clumps of the former provide a pabulum green at all seasons, though in moderate quantities only. Since both are garden plants, the butterfly's present apparently residential status in the milder of these oases cannot be primary, for no foodplant of *cardui* has been noted in a primary³ oasis at low and moderate elevations in the Middle East; if indeed the butterfly now resides and breeds continuously in these oases (which is not yet proved) this is a habit consequent on human cultivation.

³ Primary oases have been much changed by human activity; their original flora, however, can be guessed from the indigenous oasis flora still extant.

It can, however, be definitely stated that in some oases, such as Shiraz, adults are to be seen on the wing in every month of the year.

(d) Desert : *Malva parviflora*. This disappears before midsummer. Also thistles, which are more local, and also become desiccated.

Recent observations and records :—

(a) On 23rd July, 1943, I climbed To-Chal, a high mountain on the south side of the Elburz, and found adults of this butterfly extremely numerous at 9,000 ft., and plentiful but not so numerous at 8,000, 10,000, and 11,000 ft. Enormous numbers of full-grown larvae were seen on thistles at 10,000–10,500 ft. This probably indicated that about three weeks later adults would have been most numerous at this elevation, and that the mass of the *cardui* population moves up the mountain as temperature, exposure and vegetation permit.

(b) On 9th Aug., 1943, enormous numbers of adults were seen all along the track-side during a train-journey from Tehran to Qum. *Utetheisa pulchella* and several species of ACRIDIDAE and MYRMELEONIDAE were equally common, with *Colotis fausta* much more occasional. The habitat was arid steppe-desert or steppe-mountain (4,000–6,000 ft.). Thistles were common but desiccated. Presumably these adults were migrating or preparing to migrate, but the direction, if any, could not be observed. It can be readily understood that spring immigrants in this district after moving up the mountains from 4,000 ft. to their summits (here little more than 6,000 ft.) would be unable to continue the climb, as on the higher Elburz range, but must either emigrate in August or oviposit on desiccated foodplants.

(c) Among butterflies caught in the Qara Mts., Dhofar, S. Arabia, in early October by Mr. D. Vesey-Fitzgerald, I received a perfect example of *cardui*. This district is the only spot on the S. Arabian coast which receives a monsoon (summer rains). Probably it is a source of emigration for many species which spread over Arabia in winter and some of which may, instead of returning southwards to Dhofar in early summer, migrate northwards into Iraq and Iran. Certainly *cardui* would not be able to breed in the S. Arabian desert in early October.

(d) M. Charles Rungs, the French entomologist of Rabat, Morocco, informs me in a letter that *cardui* often immigrates in autumn from the south into Morocco. Morocco thus receives in autumn immigrations of *cardui* from both the north and the south, since British *cardui* are known to perform their "return-flight" at this season too.

Colias croceus Fourcroy.

Mediterranean.

General biology :—multivoltine, capacity for diapause doubtful. Neither the larva nor the pupa obtains subterranean shelter.

Principal foodplants in Middle East :—

(a) Upper and Middle Heights : no record ; presumably wild Papilionaceae.

(b) Middle Height and Desert Oases :—lucerne (alfalfa).

(c) Desert :—a small yellow vetch, presumably only available in spring and early summer, though this is not definitely confirmed.

Particular observations : the appearance of single adults early in the year at Middle Heights (e.g. in March near Tabriz, where winters are really severe, and at 6,000 ft. in Fars) may indicate a capacity for hibernation in sunny climates with a short winter, such as the Middle East and the Mediterranean basin.

General observations : from the tables it would appear that *croceus* is better able to weather unfavourable environmental conditions than *cardui*.

Glycestha aurota F. (= *mesentina*).

Tropical (Sudano-Deccanian).

Phenology and biology :—multivoltine; capacity for diapause not observed (I have never obtained a diapause in captivity); obviously incapable of surviving a cold winter of any length. The larva feeds by day and the pupa is also exposed to the effects of the climate, though not to direct sunlight.

Principal foodplant in Middle East :—*Capparis* (caper).

This species seems able to survive Middle East winters at low elevations in the area of palm-cultivations; at Middle Heights it only appears in autumn, and at Upper Heights (where the foodplant is lacking) not at all. Even at low elevations the species may depend on immigrants from farther south. In Iraq the foodplant sheds its leaves in January for a month or two. If the foodplant is present, this butterfly is apparently indifferent to the micro-climatic differences between desert and oasis. The foodplant is commonest in desert oases but occurs also in the desert in enclaves, *i.e.* not as a widespread or characteristic species.

Celerio lineata livornica Esper.

New and Old World; sub-tropical, tropical.

General biology :—multivoltine, usually without diapause. The larva feeds by day exposed in sunlight. The pupa gets shelter from its cocoon, which, however, is not completely subterranean.

Principal foodplants in Middle East :—

(a) Upper Heights, Middle Heights and Middle Height Oases : no record.

(b) Desert Oases :—*Rumex* (dock), *Vitis* (vine), etc.

(c) Desert :—*Plantago*, *Statice*, various *Cruciferae* and *Prosopis stephaniana*. The last is in leaf throughout the summer and sheds its leaves in winter; the others are vernal annuals.

There is thus available foodplant all the year round both in deserts and desert oases, so if the larva does not avail itself of the possible pabulum the climate is probably responsible.

General observations : owing to the paucity of records it is doubtful whether this species is a permanent resident anywhere in the area, though this is certainly a possibility in the desert oases. It has been observed multiplying in the desert in spring and early summer and then, after a disappearance, has been seen as an adult in the autumn. The February larvae shown in the table might be the offspring of these autumnal adults, which are presumably return-immigrants.

Agrotis ypsilon L.

Geopolitan.

General biology :—multivoltine, capacity for diapause doubtful. Larva, a night feeder. Pupa, subterranean.

Diet :—not observed in the area, but elsewhere it feeds on grasses and low plants, and is often a pest on crops.

General observations : Until the life-cycle has been followed, the appearances and absences of this moth will remain obscure. Furthermore, the records are on the scanty side, and it is doubtful whether the absences at Upper Heights in midsummer and at Middle Heights in spring are true phenological absences. The dryness of the climate may be a reason why no outbreaks of this moth as a pest have been recorded from Iraq and Iran.

Laphygma exigua Hübner.

New and Old World; sub-tropical, tropical.

General biology:—multivoltine, without diapause. The larva hides by day in the ground and feeds by night. The pupa is subterranean, and hatches in less than a week.

Foodplants in the Middle East:—

(a) Upper and Middle Heights, and Middle Height Oases: no record.

(b) Desert Oases: *Glinus lotoides*; *Hibiscus esculentus* (lady's fingers), *Vicia faba* (bean) and other crops on which it can be a pest. These are green all the summer.

(c) Desert: various low annuals, which disappear before midsummer.

General observations: the moth is remarkably more numerous in desert oases in summer than winter. The humid coolness of these oases may retard larval development in winter or may drive adults to seek drier quarters at this season. (N.B.—The winter records are all from the desert in the extreme south.) The more humid heat of the desert oases evidently provides a favourable climate for development in summer, when the desert becomes desiccated. The tables suggest that the moth emigrates for the summer from the desert to both desert oases and upper heights.

Phytometra gamma L.

Euro-Siberian.

General biology:—multivoltine, perhaps capable of hibernation. Aestivation has not been noticed. Larva feeds exposed; exposed cocoon would shelter pupa from sun, but not prevent desiccation.

Diet:—polyphagous on low plants, wild or cultivated.

General observations:—though suitable foodplants are to be found in desert oases in summer, the tables indicate that the adults cannot survive that season there; still less, in the desert. It probably survives the winter at these elevations both in the desert and the oases, in an early stage, but fuller records are needed to establish this.

Nomophila noctuella Schiffermüller.

Geopolitan.

Foodplants:—not recorded in the area, but elsewhere it feeds on low plants polyphagously.

General observations:—there is abundant evidence that this moth is a migrant and is multivoltine, even though proof that it is multivoltine by breeding is not available. The tables indicate an inability to survive summer at low elevations, even in the oases, an inability this moth shares with *gamma*; except for this, it behaves like *exigua*. It should be perhaps grouped with *livornica*.

All the above species are recognised as migrants (see Williams, 1942), so space has not been wasted in establishing, which of course they do, that they fulfil the provisions suggested above as criteria of true migrants.

Non-Migrants.

Melitaea trivia Schiffermüller.

Ranges from Portugal to N. India in Southern Palearctis, but is weakest in the West. "Anatolian-Iranian" perhaps conveys too restricted an idea

of this butterfly's geographical status, though it well indicates its headquarters.

General biology: multivoltine, able to hibernate and aestivate. Two broods precede the summer diapause, and the third (autumnal) brood is perhaps partial, for it appears to be less numerous. At Upper Heights there are probably not more than two annual broods. The larva feeds exposed in the sun. The pupa (which is the stage performing the diapause) is usually protected in a curled leaf of its foodplant.

Foodplants in the Middle East:—*Verbascum* and *Scrophularia*, the deep tap-roots of which prevent desiccation.

Habits of the adult: the females are never found far from the foodplant, but the males often seek high ground at some distance, where they like to fly and sun themselves.

It is not an oasis insect, owing to the foodplant's favouring dry ground, but might occur on a dry uncultivated patch within the circumference of an oasis.

General remarks:—the local phenology, as revealed in the table, resembles that of the migrant *livornica*, but the biological phenology, with seasonal diapauses, is different.

Polyommatus phloea L.

Euro-Pacific.

Biology:—multivoltine, able to hibernate. Neither larva nor pupa is subterranean.

Foodplants in Middle East, not recorded; presumably *Rumex* (dock).

General remarks:—the absence of this species from the southernmost desert oases and its complete absence from the true desert, together with its continuous succession of broods during the summer in those desert oases which it does inhabit, indicate an incapacity to aestivate.

D. Miscellaneous new records of other migrants.

I take this opportunity to bring forward some further evidence of migration or relevant observations of two migrants, not tabulated here but mentioned in my 1940 paper.

Colotis fausta Olivier.

(a) August 1943, see above, under *V. cardui*.

(b) Winter 1943–4, at Basra. This winter was particularly mild. *C. fausta* was seen commonly in gardens in company with *Pieris rapae* L., *Lampides baeticus* L., *Glycestia aurota* F., and *Vanessa cardui* L., throughout December and in smaller numbers through January. In mid-January the first cold winds of the winter blew for a few days but the temperature did not go below freezing on any night. By the end of January the caper bushes had shed all their leaves, but a few *fausta* were still observed. In early February more cold winds blew, and later in the month came rains and milder weather. Two *fausta* were seen on 6th March (together with more *rapae* and *cardui*). Evidently in mild winters this butterfly can survive in S. Iraq until spring, but the shedding of its foodplant's leaves may be a factor preventing year-round breeding. The normal flight of *fausta* in Iraq is during the last seven months of each year. The question may be solved by observation of the early stages, which, however, is less easy than in the case of *aurota*, the other caper-feeding migrant.

Pandesma anysa Gueneé.

Reasons for regarding this moth as a migrant were advanced in my 1940 paper. Further proof is now to be found in my capture of a specimen on the wing at sea, on board S.S. "Wo-Sang" when passing Qishm Island, Persian Gulf, on 13th July, 1942.

GENERAL DISCUSSION.

The general indication of the evidence here gathered is that insect activity is inhibited either by cold or by dry heat, and that a humid eco-climate may mitigate the inhibitory effect of the dry heat of the general climate's summer. The phenological absences of migrants and non-migrants coincide with these inhibitory maxima. Cold is stronger as a limiting factor for species with tropical headquarters, while dry heat is stronger as an inhibitor of those with temperate headquarters.

The attribution of the phenological absences shown in the tables to emigration, in the case of the migrants, and to a diapause, in the case of the non-migrants, has been discussed above and is seen to be based on our knowledge and observations of each species.

The evidence of these tables is admittedly more sketchy than that of various studies on migration made in Britain and elsewhere. Yet I feel that migrations are better studied at their source than at their terminus, that the phenology and ecology of each migrant must be studied if its migrations are to be understood, and that the absence of comparable data about migrations in sub-tropical Palearctis has given to British students a rather one-sided picture of the problem of the migration of palearctic species. It is hoped, therefore, that this study will be of value despite the scarcity of direct observations of migration and the reliance on inference from phenological and ecological details. As long as the majority of students of Palearctic Lepidoptera reside in northerly latitudes, so long will such inadequate data as are here collected have to serve for the interpretation of these migrations.

The Middle East, with its warm climate and vast arid expanses, only favourable to life for a short period of the year, is certainly one of the principal centres of emigration in the Palearctic Zone. For immigrants to Britain, situated on the extreme western edge of the Zone, the Mediterranean and N.W. Africa are the corresponding centres of emigration, but the whole of S.W. Palearctis, *i.e.* N. Africa, the Mediterranean basin and the Middle East, form a single area over which the migrants show no geographical variation and which is therefore one vast emigration-centre.

Correlations between the migrations of Lepidoptera, birds and all other migrant animals were attempted by Heape, whose book has recently been criticised by Williams (1942: 248-52). In his criticism Williams discusses the pattern of Lepidoptera migrations and the question of the return-flight. He doubts the existence of a true exodus (*i.e.* of an emigration without return) because an exodus can have no "survival value."

On this question I have formed the following views, based on the experiences and records here summarised:—

In the Middle East, Lepidoptera-migrations follow a complicated pattern, except in the case of exotic migrants (immigrating from sources outside the area), and there is no reason to suppose that the pattern of these exceptions is not equally complex in their geographical headquarters. Each species, how-

ever, has its individual pattern of migration. To describe the pattern of the indigenous migrants in terms of an emigration and a return is to over-simplify it. True, favourable winter-quarters lie to the south of favourable summer-quarters with the same climate and the same elevation in the Palearctic Region, and general northward migrations in spring and southward migrations in autumn are the consequence of this geographical fact. The greater part of the Middle East, being north of the Tropic of Cancer, *i.e.* Sub-Tropical, is traversed by these general to-and-fro migrations (there is not yet enough known about the tropical Middle East, *i.e.* S. Arabia, for its part in these migrations to be more than guessed). But altitude and eco-climate are more important than latitude in the area here discussed, and as a consequence the general picture is one of travel in many directions under environmental stimuli and of temporary or permanent settlement wherever the environment permits.

If one suppose a species to migrate only from the desert to the heights for the summer, and back to the desert for the winter, and to breed in both places, it will still be a moot point which of the two migrations is the "return-flight" but the term "return-flight" will not be inappropriate; such a picture, however, though not contrary to the facts, is an over-simplification. There is certainly no evidence that the migrants leaving the heights in autumn all "return" the way their forbears came, nor that those that do not all perish. There is indeed some evidence to suggest that at certain places in their headquarters-region at least some of the species here discussed breed all the year round and do not depend on the return of emigrants; with better knowledge of these regions it will eventually become clear if this is really so. It is also already clear that there are many alternative biotopes scattered all over the area to which an emigrant, or its offspring, may return at the end of the season and survive. The spring-migration of *exigua* from the desert is in part a "return" to the oases (where it probably breeds in small numbers all the year round and certainly multiplies in summer) and also in part an emigration to the heights (where it does not breed all the year round, and where it apparently multiplies less). The term "return-flight" is inappropriate here, and Heape's alternatives "climatic-alimental" or "nomadic" are less inept. Perhaps "return-flight" better describes migrations towards a biotope or region where the migrant resides permanently, *e.g.* the southward migration in the autumn from Britain of a sub-tropical migrant. The term, however, has often been used to cover all southward migrations from northerly latitudes in autumn; but even if its use is confined to these migrations it may be misleading, for it lumps together two different southward autumnal migration types, *viz.*: (1) the migration towards the geographical headquarters and (2) the migration away from it; it also lumps together two biologically different migration-types, *viz.*: (1) the migration towards a winter-rest area (*e.g.* *D. plexippus* and probably *V. atalanta*) and (2) towards a winter-breeding area (*e.g.* *V. cardui*). The question of the "return-flight," therefore, even in northerly latitudes, is not one which can be discussed generally, and the evolution of the migration pattern is a separate problem for each migratory species. Only in a few cases is the pattern definite enough to justify speaking of its evolution.

It is thus pointless to discuss the supposed "survival value" of an "exodus" or of a migration complete with "return-flight." The idea of "survival-value" is anyhow theoretical, and if an apparent fact does not fit in with a theory, it is on the theory that the doubt must first fall. For those anxious to retain the idea of evolution by natural selection, and to discover a

"survival value" in all recurring natural phenomena, it is suggested that the migratory capacity, rather than the migration or migratory pattern itself, is the thing in insect migrations which has evolved in this way.

The supposed evolution may thus have taken place in two alternative directions:—towards (1) a highly-developed migratory capacity, or (2) a highly-developed capacity for diapause. The latter capacity would appear, from Sutton's record of *livornica*, already discussed, to be latent in at least some of the species in which the migratory capacity is well developed; but, as has been shown, the evidence suggests that once a species has fully developed one of the alternative capacities, a return to the other is impossible for the mass of the population. It is probably a genetic process which decides, at the critical point in the evolution of a species, whether it will evolve in one or the other direction; the decision may also be the outcome of the process of natural selection, in which case both the evolving capacities have a survival-value; but this is a speculation on which it is unnecessary to expatiate further here.

The evidence here collated is, unfortunately, inconclusive on the problem whether any of these migrants breed all the year round on any single biotope in the area. This is probably the case with *exigua*, in desert oases, but in other cases it is more doubtful, or plainly not the case. But all eight of the migrants here tabulated, with the probable exception of *aurora*, and the doubtful exception of *ypsilon*, can survive by migrating within the area, and *aurora* can if the area is enlarged to include all Arabia. While the area is vast (a thousand miles from east to west, and five hundred from north to south), the minimum distance separating favourable summer from winter quarters for such a migrant as *cardui* is not great, in fact about thirty miles only; indeed a distance of about fifty miles separates the Upper Heights from the Desert for hundreds of miles along the great Zagros Range, running N.W.—S.E. across the area. Such species could thus permanently survive in the area by performing a spring and an autumn migration of no more than fifty miles. Whether certain populations do indeed confine themselves to so short a migration it is impossible to judge; probably the length of the journey depends on momentary environmental conditions or on the individual's biological condition; individuals venturing the farthest afield will be less likely to perpetuate their kind than those the migrations of which are of a more moderate extent, in this particular region.

The migratory capacity thus enables these eight species to populate, at least temporarily, more localities than they could populate without it, and is responsible for their commonness throughout the Middle East. The word "instinct" implies a precise pattern indispensable for survival, and the actual migrations here studied are too haphazard to deserve this description.

UNSOLVED PROBLEMS.

Among other lessons, this study has demonstrated what Williams has already stressed, that the problems of migration require that particular and constant attention be paid to the species concerned. In the Middle East, the migrants are so common that the entomologist is tempted very soon to pay them less attention and to concentrate on discovering new species or on working out the biology of little known species. If this study serves to direct the attention of entomologists residing in suitable regions to these problems, it will have served its purpose. Particular questions still unsolved in the Middle East are:—

(1) Does *V. cardui* really survive the summer, even in small numbers, in desert oases, and does it actually breed all the year round in places where it flies all the year round?

(2) Does *G. aurora* survive the summer at all in the area?

(3) Are autumnal *livornica* females the parents of the larvae to be found in deserts and desert oases in early spring?

PRACTICAL VALUE OF THESE STUDIES.

The proper understanding of Lepidoptera migrations has its practical value, since many of the most pestilential species are also migrants. Five of the eight migrants here studied have been recorded as damaging crops.

SUMMARY.

Tables compiled from 278 single records of eight migrants and two non-migrants in the Middle East show the appearances and absences of these ten species of Lepidoptera on different types of biotope during the calendar year. The absences coincide in general with maximum unfavourable climatic conditions, viz.: (a) cold, and (b) dry heat. It is concluded from knowledge of the species that the absences of the eight migrants imply an emigration of the mass of the population. These migrations are, in general, towards the Upper Heights and away from the deserts in early summer, and vice versa in autumn. The most obvious exception to this generalisation is *G. aurora*, which does not reach Upper Heights and which, it would seem from the tables, dies out every summer in the area considered. *A. ypsilon* also appears to be an exception but the tabled absences in this case are of doubtful significance. In a few species, notably *L. exigua*, the migration from the desert is to the desert oases for the summer as well as to the heights. In some oases *V. cardui* is seen all the year round, but this is thought to be due to the presence of foodplants and flowers which are secondary in these biotopes and the result of human activity. Each species has its individual ecological requirements and its own migration pattern. This pattern cannot be considered in simple terms of an "emigration" and a "return-flight" in the headquarters-region of a migrant, though on the fringes of its absolute distribution this interpretation of its movements is less objectionable. The zoogeographical status of the species is given, and its importance stressed. The evolution of the migratory capacity is briefly discussed. The evolution of the migration pattern is not discussed, since this would be a separate question for each species.

The wide variation in the rainfall from year to year is mentioned among other features of the climatic environment. Possible causes of, or periodicity in, migratory outbreaks are, however, not discussed, the Middle-East migrations under consideration being annual reactions to seasonal changes in the environment. The Middle East as a whole, however, is an important source of emigration for Palearctic Lepidoptera. Most of the migrants in question do not need to migrate out of the area to survive permanently. The migrations within the area enable them to populate many places unsuitable for year-round residence. The Middle East, however, considered as a source for Palearctic migrants, cannot really be separated from the whole of S.W. Palearctis.

ACKNOWLEDGEMENTS.

I wish to express my debt to Dr. B. P. Uvarov, C.M.G., for his invaluable criticisms on the first draft of this paper. These related to the form and scope of the paper and did not affect my general views on the problems of insect migration, except insofar as I was encouraged to undertake the revision of the paper by the favourable comments on those views.

I am also indebted, like all students of insect-migration, to Dr. C. B. Williams, who has both contributed so much and inspired so many other contributions to the knowledge of these phenomena.

REFERENCES.

- BODENHEIMER, F. S., 1935, *Animal Life in Palestine* : 203.
- PEILE, H. D., 1921-22 (with other collaborators), Butterflies of Mesopotamia. *J. Bombay nat. Hist. Soc.* **28** : 345-369.
- SCHWINGENSCHUSS, L., 1940, Beitrag zur Lepidopteren-Fauna von Iran. *Ent. Z.* **52-53**.
- SUTTON, G. P., 1944, *Celerio livornica* : delayed emergence. *Entomologist* **77** : 192.
- WILLIAMS, C. B., and others, 1942, Studies in the migration of *Lepidoptera*. *Trans. R. ent. Soc. Lond.* **92**.
- WILTSHIRE, E. P., 1940, Some notes on migrant *Lepidoptera* in Syria, Iraq and Iran. *Entomologist* **73** : 231.
- , 1941, Mesopotamian desert *Lepidoptera*. *J. Bombay nat. Hist. Soc.* **42** (4).

GENERAL INDEX

A

abdycalis, Rhynchina, 70.
Acanthagrion apicale, 36.
Acanthagrion apicale descendens subsp.n., 38.
Acanthagrion apicale luna, 38.
Acanthagrion gracile floridense subsp.n., 37.
ace, *Arhopala ace*, 83.
aces, *Arhopala corinda*, 84.
Acontia spp., 67.
Acronicta bicolor, 62.
Acronicta indica, 64.
Acronicta pruinosa, 62.
Acronicta rubiginosa, 62.
Aedes apicoargenteus, 110.
Aedes (Aedimorphus) capensis, 119.
Aedes (Aedimorphus) kapretivae, 118.
Aedes (Aedimorphus) pseudotarsalis sp.n., 119.
Aedes, key to known larvae, 122.
Aedes (Stegomyia) deboeri, 112.
Aedes (Stegomyia) deboeri subsp. *demeillion*, 113.
Aedes (Stegomyia) fraseri, 109.
Aedes (Stegomyia) rheniensis sp.n., 111.
AETHALIONIDAE, 58.
aeolus, *Elsianus*, 139.
AESHNIDAE, 11.
Adisura atkinsoni, 65.
adjuncta, *Polythore derivata*, 18.
agelastus, *Arhopala agelastus*, 84.
agesias, *Arhopala*, 82.
agilis, *Hartigia*, 98.
Agrion (Calopteryx), 12.
Agrion gracile, 36.
Agrotis ypsilon, 175.
aldrichii, *Caenoccephus*, 98.
alemon, *Arhopala*, 83.
allata, *Arhopala*, 81.
aleus, *Elsianus*, 138.
amanus, *Elsianus*, 137.
ambigua, *Polythore derivata*, 19.
Amyna spp., 67.
Androlymnia emarginata, 68.
antimuta, *Arhopala antimuta*, 83.
antiquus, *Elsianus*, 148.
anyssa, *Pandesma*, 178.
apicale, *Acanthagrion*, 36.
apicoargenteus, *Aedes*, 110.
Arhopala ace ace, 83.
Arhopala achelous malu subsp.n., 78.
Arhopala agelastus agelastus, 84.
Arhopala agelastus enoma subsp.n., 85.
Arhopala alemon, 83.
Arhopala agesias, 82.
Arhopala agrata binghami subsp.n., 83.
Arhopala allaba, 81.
Arhopala antimuta antimuta, 83.
Arhopala asia, 82.
Arhopala atosia udapa, 80.
Arhopala atraz, 83.
Arhopala camdeo, 78.
Arhopala camdeo camdana, 79.
Arhopala camdeo fruhstorferi, 79.
Arhopala camdeo franthera subsp.n., 79.

Arhopala cooperi whiteheadi subsp.n., 83.
Arhopala corinda aces, 84.
Arhopala dispar, 79.
Arhopala epimula epiala, 82.
Arhopala eumolphus, 84.
Arhopala hellada ozana, 78.
Arhopala horsfieldi basiviridis, 84.
Arhopala labuana labuana, 85.
Arhopala malayana, 80.
Arhopala myrzala lammas, 78.
Arhopala pseudomuta, 81.
Arhopala rafflesii, 83.
Arhopala, relative abundance of Malayan species, 74.
Arhopala semperi, 80.
Arhopala tropaea, 82.
arabicus, *Circulifer*, 161.
ARCTIIDAE, 61.
armigera, *Heliothis*, 65.
aristaeus, *Elsianus*, 134.
asia, *Arhopala*, 82.
ATHETOCEPHINAE, 105.
Athetocephus madecassus, 105.
Athetocephus maculatus, 105.
atkinsoni, *Adisura*, 65.
atraz, *Arhopala*, 83.
aurora, *Polythore*, 23.
aurota, *Glycestha*, 175.

B

basiviridis, *Arhopala horsfieldi*, 84.
beata, *Polythore*, 23.
bicolor, *Acronicta*, 62.
binghami, *Arhopala agrata*, 83.
biplagiata, *Heliona*, 152.
Bocula hypenoides, 67.
Bomolocha occata, 70.
Bomolocha triangularis, 71.

C

Caenoccephus, 98.
Caenoccephus aldrichii, 98.
Caenoccephus jakowleffi, 98.
Calameuta, 104.
Calameuta, list of species now included, 104.
camdana, *Arhopala camdeo*, 79.
camdeo, *Arhopala*, 78.
capensis, *Aedes (Aedimorphus)*, 119.
cardinalis, *Oxyagrion*, 41.
carinata, *Coriza*, 3.
cardui, *Vanessa*, 173.
caspus, *Circulifer*, 160.
CATOCALINAE, 61.
cavifrons, *Glaenocoris*, 1.
Celerio lineata livornica, 175.
celsus, *Elsianus*, 145.
Cephalocephus, gen.n., 96.
Cephalocephus xanthus sp.n., 100.
Cetola dentata, 62.

CEPHIDAE, key to Subfamilies and Tribes, 91.
 Cephidae, List of British, 106.
 CEPHINAE, key to Genera of HARTIGIINI, 93.
Cephus brachycercas, 103.
Cephus cinctus, 103.
Cephus clavatus, 103.
Cephus cultratus, 103.
Cephus femoratus, 98.
Cephus fumipennis, 103.
Cephus hyalinatus, 103.
Cephus lateralis, 103.
Cephus nigrinus, 103.
Cephus nigripennis, 102.
Cephus pygmaeus, 98.
Cephus runcator, 103.
Cephus sachalinensis, 103.
Cephus itanaiticus, 103.
Chalcopteryx, 12.
champa, *Diphthera*, 62.
Characopygus moricei, 101.
Characopygus scythicus, 101.
Chasmina judicata, 67.
Chasmina tibialis, 67.
chinai, *Circulifer*, 160.
Cicadulina bipunctilla zeae, 157.
Cicadulina mbila, 159.
Circulifer arabicus sp.n., 161.
Circulifer caspius, 160.
Circulifer chinai sp.n., 160.
Circulifer jenjouriste sp.n., 161.
clavatus, *Cephus*, 103.
codrus, *Elsianus*, 147.
 COENAGRIIDAE, 11.
Colias croceus, 174.
Colotis fausta, 177.
concinna, *Polythore*, 22.
connectens, *Janus*, 98.
conscitatis, *Hypena*, 70.
conspersa, *Simyra*, 62.
Cora, 12.
Coriza carinata, 3.
Coriza distincta, 8.
Coriza germari, 3.
croceus, *Colias*, 174.
cruentatus, *Pachycephus*, 101.
cupraea, *Mnesarte*, 31.

D

deboeri, *Aedes* (*Stegomyia*), 112.
demeillon, *Aedes* (*Stegomyia*) *deboeri*, 113.
dentata, *Cetola*, 62.
denticulata, *Neoneura*, 43.
derivata, *Polythore*, 16.
descendens, *Acanthagrion apicale*, 38.
devillei, *Mnesarte*, 30.
Dichromia orosa, 70.
Dichromia trigonalis, 70.
Diphthera champa, 62.
dispar, *Arhopala*, 79.
distincta, *Coriza*, 8.

E

Elsianus aeolus sp.n., 139.
Elsianus aleus sp.n., 138.
Elsianus amanus sp.n., 137.
Elsianus antiquus, 148.

Elsianus aristaeus sp.n., 134.
Elsianus celsus sp.n., 145.
Elsianus codrus sp.n., 147.
Elsianus tsus sp.n., 129.
Elsianus, key to Brazilian Species, 126.
Elsianus plaumanni sp.n., 143.
Elsianus saleis sp.n., 144.
Elsianus tereus sp.n., 134.
Elsianus thorpei sp.n., 131.
Elsianus tityrus sp.n., 133.
Elsianus zamus sp.n., 141.
Elydna transversa, 67.
emarginata, *Androlymnia*, 68.
Empoasca minor sp.n., 151.
enoma, *Arhopala agelastus*, 85.
epiala, *Arhopala epimuta*, 82.
eumolphus, *Arhopala*, 84.
 EURYMELIDAE, 58.
Euthore, 12.
Euthore modesta, 24.
exigua, *Laphygma*, 176.

F

fausta, *Colotis*, 177.
femoratus, *Cephus*, 98.
floridense, *Acanthagrion gracile*, 37.
fraseri, *Aedes* (*Stegomyia*), 109.
fruhstorferi, *Arhopala camdeo*, 79.

G

gamma, *Phytometra*, 176.
germari, *Coriza*, 3.
gigantea, *Hartigia*, 97.
gigantea, *Polythore*, 15.
Glaenocorisca cavifrons, 1.
Glaenocorisca propinqua, 1.
Glycestha aurota, 175.
 GOMPHIDAE, 11.
gracile, *Agrion*, 36.

H

HADENINAE, 61.
Haplocephus aureus, 102.
Hartigia, 96.
Hartigia agilis, 98.
Hartigia gigantea, 97.
Hartigia linearis, 97.
Hartigia niger, 97.
Hartigia nigrata, 97.
Hartigia sibiricola, 98.
Hartigia viator, 98.
hauzwelli, *Mnesarte*, 28.
Heliona biplagiata, 152.
Heliona statice, 153.
Helionidia himyarita sp.n., 155.
Helionidia gen.n., 152.
Heliothis armigera, 65.
Hemiodoccus, 50.
Heterina papavarina sp.n., 33.
 HETAERINIDAE, 11.
hinyarita, *Helionidia*, 155.
hincksi, *Mnesarte*, 26.
 HYLLIOIDAE, 58.
Hypena conscitatis, 70.

Hypenai conicalis, 70.
Hypena ignotalis, 70.
Hypena proboscialis ab. *indicalis*, 70.
Hypena rectivittalis, 70.
Hypena sublividalis, 70.
Hypena uniformis, 70.
 HYPENINAE, 61.
hypenoides, *Bocula*, 67.

I

iconicalis, *Hypena*, 70.
ignotalis, *Hypena*, 70.
indica, *Acronicta*, 64.
indicalis, *Hypena proboscialis*, 70.
isus, *Elsianus*, 129.

J

Janus abbreviatus, 99.
Janus bimaculatus, 100.
Janus compressus, 99.
Janus connectens, 98.
Janus integer, 99.
Janus kashivorus, 99.
Janus luteipes, 99.
Janus malaisei sp.n., 99.
Janus nigratus, 97.
Janus nigromaculatus, 100.
Janus rufiventris, 99.
jakowleffi, *Caenocephus*, 98.
 JASSIDAE, 58.
jaxartensis, *Zygina*, 153.
jenfouriste, *Circulifer*, 161.
Josocora, 12.
judaicus, *Microcephalus*, 102.
judicata, *Chasmina*, 67.

K

Kalocora, 12.
kapretivae, *Aedes (Aedimorphus)*, 118.
kashivorus, *Janus*, 99.
keniensis, *Aedes (Stegomyia)*, 111.

L

labuana, *Arhopala labuana*, 85.
lammas, *Arhopala myrzala*, 78.
Laphygma exigua, 176.
 Leaf-hoppers, key to position within the
Homoptera-Auchenorrhyncha, 57.
libanensis, *Trachelus*, 90.
linearis, *Hartigia*, 97.
livornica, *Celerio lineata*, 175.
luna, *Acanthagrion apicale*, 38.
lutaria, *Sialis*, 53.
luteipes, *Janus*, 99.

M

Macrosteles seznotata, 160.
maculatus, *Athetoccephus*, 105.
madecassus, *Athetoccephus*, 105.
magnifrons, *Paurocephala*, 50.
malaisei, *Janus*, 99.

malayana, *Arhopala*, 80.
malu, *Arhopala achelous*, 78.
mbila, *Cicadulina*, 159.
Melittae trivialis, 176.
 MEMBRACIDAE, 58.
Microcephalus judaicus, 102.
Miocora, 12.
minor, *Empoasca*, 151.
Mnesarte cupraea, 31.
Mnesarte devillei, 30.
Mnesarte hauxwelli, 28.
Mnesarte hincksi sp.n., 26.
modesta, *Euthore*, 24.
Monoplopus, 104.
morecei, *Characopygus*, 101.
mutata, *Polythore*, 24.

N

Neoneura denticulata, 43.
niger, *Hartigia*, 97.
nigra, *Putoniessa*, 48.
nigrata, *Hartigia*, 97.
nigratus, *Janus*, 97.
nigratus, *Pachycephalus*, 97.
noctuella, *Nomophila*, 176.
 NOCTUIDAE, 61.
Nomophila noctuella, 176.

O

occata, *Bromolocha*, 70.
originata, *Polythore derivata*, 18.
orosa, *Dichromia*, 70.
Oxyagrion cardinalis sp.n., 41.
Oxyagrion terminale, 40.
ozana, *Arhopala hellada*, 78.

P

Pachycephalus cruentatus, 101.
Pachycephalus nigratus, 97.
Pachycephalus smyrnensis, 90.
Pachycephini, key to genera, 101.
Pachycephini trib.n., 101.
Pandesma anysa, 178.
panthera, *Arhopala camdeo*, 79.
papavarina, *Hetaerina*, 33.
parreysii, *Syrista*, 100.
Paurocephala magnifrons, 50.
 PELORIDIIDAE, 52.
phlocas, *Polyommatus*, 177.
Phytometra gamma, 176.
 PHYTOMETRIDAE, 61.
picta, *Polythore*, 14.
plaumanni, *Elsianus*, 143.
Polyommatus, *phlocas*, 177.
Polythore, 12.
Polythore aurora, 23.
Polythore beata, 23.
Polythore concinna, 21, 22.
Polythore derivata, 16.
Polythore derivata race *ambigua* n., 19.
Polythore derivata race *adjuncta* n., 18.
Polythore derivata race *originata* n., 18.
Polythore derivata race *terminata* n., 20.
Polythore gigantea, 15.

Polythore mutata, 24.
Polythore picta, 14.
Polythore victoria, 16.
Polythore vittata, 21.
 POLYTHORIDAE, 11.
postica, *Thiacidas*, 62.
pseudomuta, *Arhopala*, 81.
pseudotarsalis, *Aedes* (*Aedimorphus*), 119.
propinqua, *Glaenocoris*, 1.
Protophore, 12.
pruinosa, *Acronicta*, 62.
Putoniessa nigra, 48.
pygmaeus, *Cephus*, 98.
Pyrrhia umbra, 65.
rafflesii, *Arhopala*, 83.
rectivittalis, *Hypena*, 70.

R

Rhynchina abducalis, 70.
rubiginosa, *Acronicta*, 62.
rufiventris, *Janus*, 99.

S

saletus, *Elsianus*, 144.
sachalinensis, *Cephus*, 103.
semperi, *Arhopala*, 80.
sexnotata, *Macrosteles*, 160.
Sialis lularia, 53.
sibiricola, *Hartigia*, 98.
similis, *Syrista*, 100.
Simyra conspersa, 62.
smyrnensis, *Pachycephus*, 90.
staices, *Heliona*, 153.
Stegomyia, key to Ethiopian Species, 123.
Stenocora, 12.
sublividalis, *Hypena*, 70.
 SYNTETIDAE, 89.
Syrista parreysii, 100.
Syrista speciosa, 100.
Syrista similis, 100.

T

Tamaricella subgen.n., 153.
Telebasis versicolor sp.n., 42.
tereus, *Elsianus*, 134.
terminale, *Oxyagriton*, 40.
terminata, *Polythore derivata*, 20.
Thiacidas postica, 62.

thorpei, *Elsianus*, 131.
tibialis, *Chasmina*, 67.
tityrus, *Elsianus*, 133.
Trachelus armenius, 104.
Trachelus flavicornis, 104.
Trachelus judaicus, 104.
Trachelus libanensis, 90.
Trachelus tabidus, 104.
Trachelus tenuicornis, 104.
Trachelus tigris, 104.
Trachelus troglodyta, 104.
transversa, *Elydna*, 67.
triangularis, *Bomolocha*, 70.
trigonalis, *Dichromia*, 70.
trivia, *Melitae*, 176.
tropaea, *Arhopala*, 82.

U

udapa, *Arhopala atosia*, 80.
umbra, *Pyrrhia*, 65.
uniformis, *Hypena*, 70.

V

Vanessa cardui, 173.
versicolor, *Telebasis*, 42.
viator, *Hartigia*, 98.
victoria, *Polythore*, 16.
vittata, *Polythore*, 21.

W

whiteheadi, *Arhopala cooperi*, 83.

X

xanthus, *Cephalocephus*, 100.
 XIPHYRIDAE, 89.

Y

ypsilon, *Agrotis*, 175.

Z

zamus, *Elsianus*, 141.
zeae, *Cicadulina bipunctella*, 157.
Zygina jaxartensis, 153.

